Basel Convention on Hazardous Wastes

OFFICE OF ENVIRONMENTAL QUALITY

Overview

The **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal** controls the international trade in hazardous wastes and certain other wastes. The Convention, which was adopted in 1989 and entered into force in 1992, establishes a "notice and consent" regime — also known as prior informed consent (PIC) — for the export of hazardous and certain other waste to importing countries. Under the Convention's provisions, trade in such wastes generally cannot take place:

- without the importing country's written consent; or
- when the exporting country has reason to believe that the particular wastes will not be handled in an environmentally sound manner.

Currently, there are 188 Parties to the Convention. The United States signed the Basel Convention in 1990. The U.S. Senate provided its advice and consent to ratification in 1992. The United States, however, has not ratified the Convention because it does not have sufficient domestic statutory authority to implement all of its provisions.

Plastic Waste Amendments

In 2019, Parties to the Basel Convention adopted **amendments** to Annexes II, VIII, and IX that will subject the majority of exports of plastic waste and scrap to the Convention's PIC requirement starting January 1, 2021. The Convention's non-party trade restrictions prohibit Parties from trading in covered waste and scrap subject to PIC with non-Parties, except under the terms of an agreement or arrangement provided for by Article 11 of the Convention.

Article 11 Arrangements and Agreements

Article 11 of the Basel Convention provides that, notwithstanding the Convention's non-Party trade restriction, Parties may enter into agreements or arrangements allowing transboundary movement of hazardous wastes or other wastes with Parties or non-Parties, provided that such agreements or arrangements (1) do not derogate from the Convention's requirements for environmentally sound management and (2) stipulate provisions which are not less environmentally sound than those provided for by the Convention. Such Article 11 agreements or arrangements enable Basel Parties to trade in waste and scrap covered by the Convention's PIC procedures with non-Parties (like the United States) The United States has entered into several such agreements or arrangements, as described below.

OECD Council Decision

The **Organization for Economic Co-operation and Development (OECD) Council Decision on the Control of Transboundary Movements of Wastes Destined for Recovery Operations** serves as an Article 11 agreement that enables the United States to trade certain Basel Convention covered wastes with other OECD countries. Wastes subject to the OECD Control System are listed in Appendices 3 (the Green List) and 4 (the Amber List) of the OECD Council Decision and are incorporated by reference in 40 CFR Part 262, Subpart H; the Appendices partially mirror the Basel Convention Annexes.

Bilateral Article 11 Agreements and Arrangements between the United States and other Countries:

Canada – The 1986 *Agreement Between the Government of the United States of America and the Government of Canada Concerning the Transboundary Movement of Hazardous Waste and Other Waste*, as amended in 1992, addresses the transboundary shipment of hazardous waste and municipal solid waste between the two countries. The bilateral agreement, among other goals, seeks to provide both countries with safe, low cost options for managing waste for which there is a lack of either domestic capacity or technology to appropriately manage the waste.

The 2020 **Arrangement Between the Government of the United States of America and the Government of Canada Concerning the Environmentally Sound Management of Non-Hazardous Waste and Scrap Subject to Transboundary Movement** **[395 KB]** addresses bilateral trade in non-hazardous waste and scrap, including non-hazardous plastic waste and scrap, while affirming the environmentally sound management in each country of non-hazardous waste and scrap that is subject to transboundary movement between the two countries.

Mexico – The 1986 *Agreement of Cooperation Between the United States of America and the United Mexican States Regarding the Transboundary Shipments of Hazardous Wastes and Hazardous Substances* (concluded as Annex III to the Agreement Between the United States of America and the United Mexican States on Cooperation for the Protection and Improvement of the Environment in the Border Area), as amended, addresses the transboundary shipment of hazardous wastes and hazardous between the two countries.

Costa Rica, Malaysia and the Philippines also have Article 11 agreements with the United States. These agreements address the import of hazardous waste from those countries into the United States, but not export from the United States to those countries.

TAGS

Climate and Environment | Environment

MINAMATA CONVENTION ON MERCURY

TEXT AND ANNEXES

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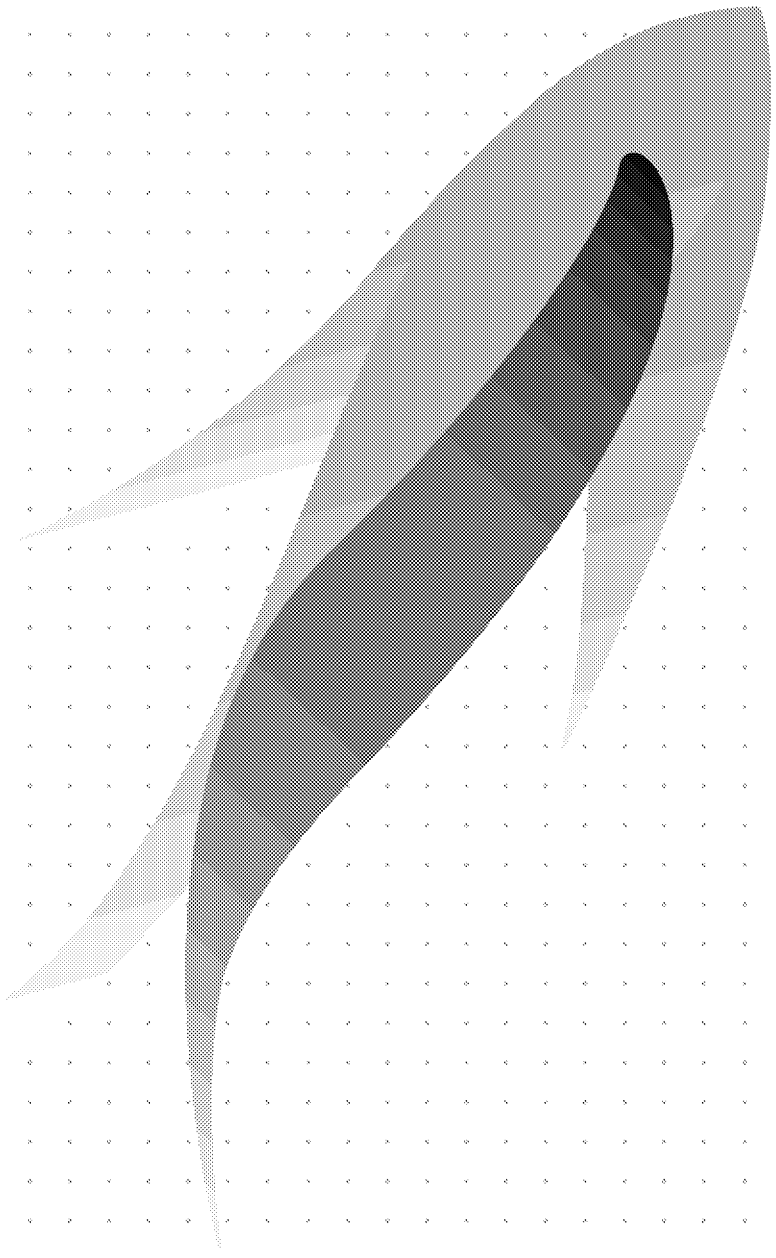
www.mercuryconvention.org

September 2019

UN environment

United Nations
Environment Programme



FOREWORD BY THE SECRETARY-GENERAL OF THE UNITED NATIONS
ANTÓNIO GUTERRES

In 1956, two sisters, aged two and five, were diagnosed in Minamata Bay, Japan, with the crippling, untreatable and stigmatizing effects of mercury poisoning. In the decades that followed, their story would be retold many times, becoming synonymous with the tens of thousands of adults, children and unborn infants to suffer from what is now known as Minamata disease.

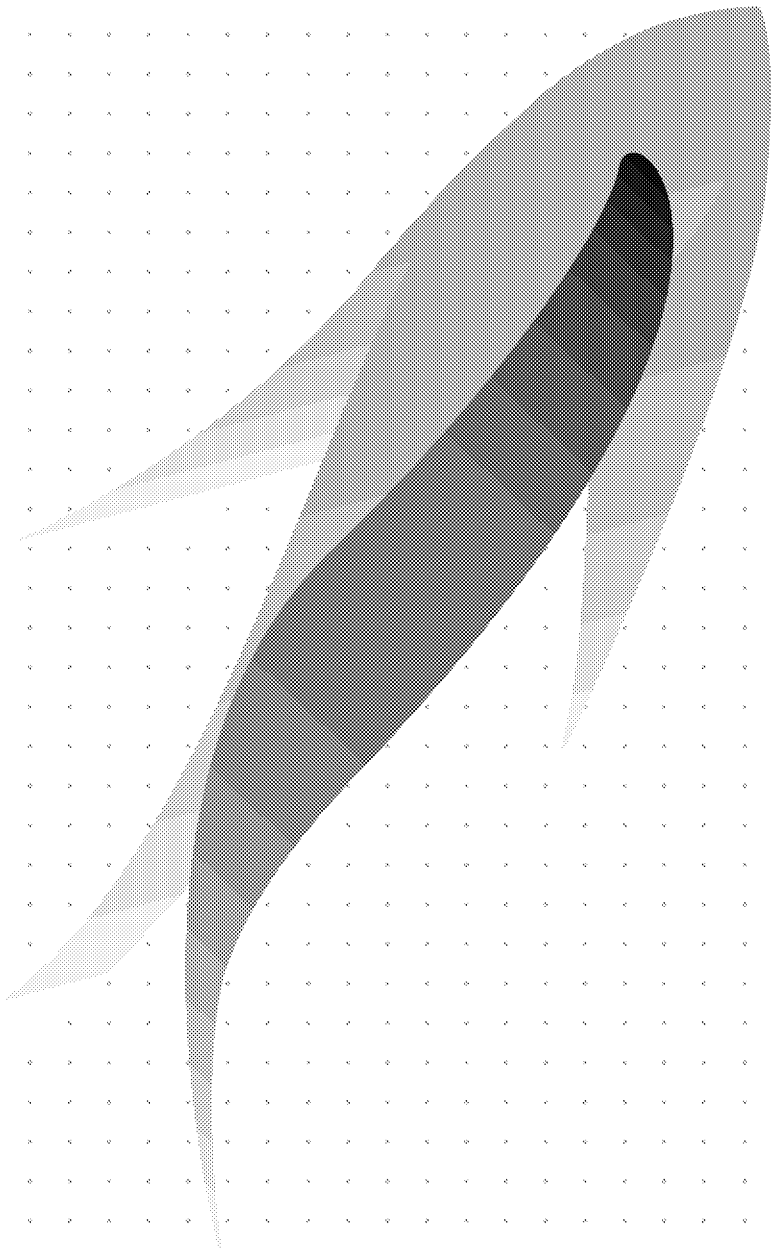
Unfortunately, it is a story that we still need to tell because, decades on, too many people still think of mercury simply as a fascinating element safely contained in thermometers. Too few understand that it is lethal, indestructible and present in everything from coal-fired power generation to certain mascaras and fluorescent lights. Likewise, too many are unaware that just a fraction of the 130,000 chemicals and other substances on the market are properly assessed, labelled and tracked. Even fewer suspect that items as mundane as pizza boxes, microwave popcorn or electronic waste pollute our air, land, water, food chains and ecosystems for generations. It still takes far too long to identify, accept and act on such risks to human health.

We need to reinforce the right of scientists to pursue their work for the greater good and for medical experts and citizens to access that knowledge easily. And we need to insist on the right and responsibility of judiciaries and governments to act on such knowledge and the right of the media to report on the outcomes and implications of all these efforts. These are basic rights highlighted by the tragic past and optimistic future that the Minamata Convention symbolizes.

Like so many contaminants, mercury doesn't just damage individual victims. It damages entire communities. It fuels poverty, feeds conflict and pushes equality further out of reach. Take the example of a young mother working as an artisanal gold miner. While she is poisoned from handling mercury at work, countless others, including her children, are harmed by its impact on the environment.

The Minamata Convention is our chance to break that cycle of misery. It represents an opportunity to not only improve the health of people around the world, but to accelerate the transition to a fairer, greener economy. People can benefit from technology that offers safer, more effective alternatives for communities to build a more stable, sustainable future. The legal waste market, which is already worth $400 billion a year, can create more jobs to securely handle the 90 per cent of electronic waste currently left to pollute our health and our environment. Quite simply, the potential benefits are enormous.

I thank everyone who has already worked so hard to ratify this Convention. But the hardest work still lies ahead, because now we must implement it swiftly and effectively to minimize the risks posed to communities in all regions by the toxic threat of mercury poisoning.



FOREWORD BY UN UNDER-SECRETARY-GENERAL AND EXECUTIVE DIRECTOR OF UN ENVIRONMENT

INGER ANDERSEN

Surrounded by forests and blue sea, Minamata Bay, in Japan, gives the impression of an idyllic place. But it was not always like this. A memorial erected a few meters from the coast serves as a reminder of the local communities that were poisoned by mercury in the late 1950s.

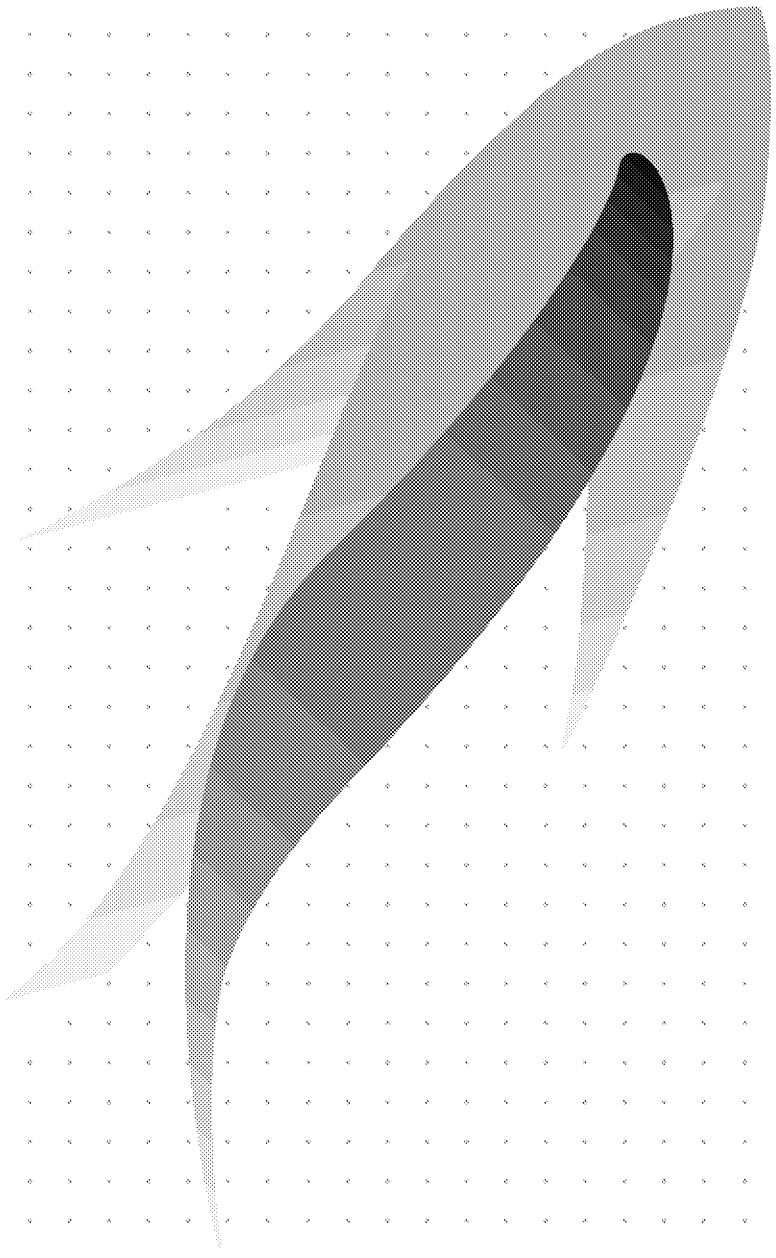
Through the Minamata Convention on Mercury, the global community remembers the many lives already lost to mercury poisoning and commits to preventing similar catastrophes. It is the first global environmental agreement addressing one of the biggest challenges to human health and the environment, from anthropogenic emissions and the release of mercury and mercury compounds.

Mercury exposure is a global concern. Every year, as much as 9,000 tons of mercury are released into the atmosphere, in water and on land. The largest source of mercury emissions is artisanal and small-scale gold mining, followed closely by coal combustion, non-ferrous metal production and cement production. And we still find mercury in many commercial products such as batteries, fluorescent lamps, cosmetics, pesticides, thermometers and dental amalgams. Everyone is exposed to some amount of mercury and high amounts of mercury can lead to long-term and sometimes permanent neurological damages.

The Minamata Convention which entered into force in August 2017, provides a powerful impetus to global efforts to reduce and eliminate the use of mercury and mercury compounds. The international community is working hard to comply with the measures established in the Convention as well as with the related-Sustainable Development Goals to move towards our common goal of prosperity for people and the planet.

A key priority in coming years is to shift investments from mercury polluting industries, in favour of investments in renewable energy, nature, research and development. In doing so, we must capture the opportunities of affordable technologies and innovations that can move markets in the right direction. With greater ambition we will all step up and step in with new solutions to ensure the effective implementation of the Minamata Convention on Mercury.

For the good of our planet, for our future generations, it is time to take action and make mercury history!



FOREWORD BY HER EXCELLENCY (MRS.) DORIS LEUTHARD, PRESIDENT OF THE SWISS CONFEDERATION AND MINISTER FOR THE ENVIRONMENT, TRANSPORT, ENERGY AND COMMUNICATIONS ON THE OCCASION OF THE FIRST MEETING OF THE CONFERENCE OF THE PARTIES TO THE MINAMATA CONVENTION (GENEVA, 24-29 SEPTEMBER 2017)

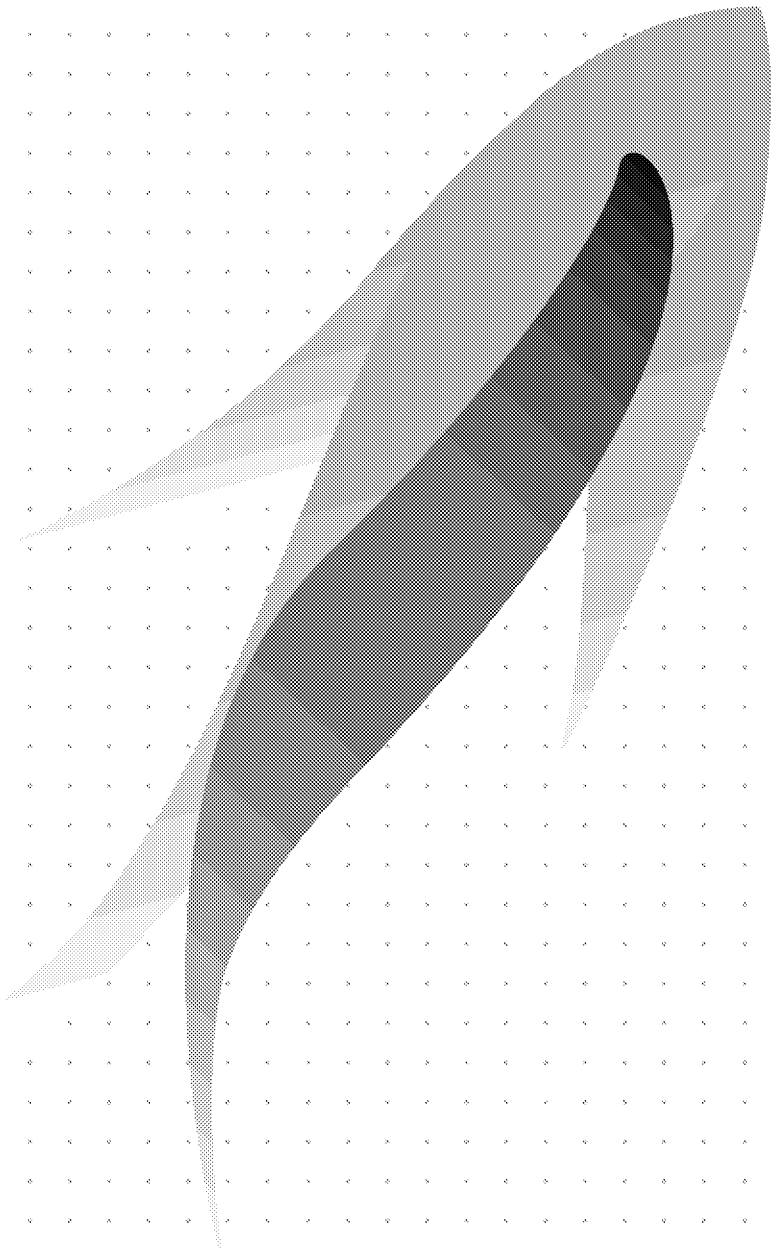
The Minamata Convention is the first global environmental agreement negotiated in the 21st millennium. It reflects an innovative and comprehensive approach, addressing mercury throughout its life cycle from its mining to its management as waste. It is a privilege and honor for me to host the first Conference of the Parties to the Minamata Convention in Geneva, Switzerland.

In 2003, the Global Mercury Assessment was presented to the 22nd UNEP Governing Council. It concluded that there is significant global adverse impacts from mercury and its compounds to warrant further international action. In response, Switzerland, together with Norway, proposed to develop a comprehensive legally binding instrument on mercury. It took 6 years and many efforts of formal and informal discussions and outreach until the UNEP Governing Council decided in 2009 at its 25th session to launch negotiations for a global mercury convention. These negotiations were well organized and prepared by UNEP Chemicals. They benefitted from substantive input from competent intergovernmental institutions as well as nongovernmental organizations. And, they were guided by the president of the negotiation process, ambassador Fernando Lugris from Uruguay, in a diligent, wise and solution oriented manner.

In 2013, 10 years after Switzerland's and Norway's call for a legally binding instrument for mercury, the 5th session of the Intergovernmental Negotiation Committee concluded its negotiations in Geneva. I very well remember the final negotiations in Geneva and the pride and satisfaction, when on Saturday morning, 19 January 2013, at 7 am, after a long week of intensive negotiations, agreement on the text of the Minamata Convention on Mercury was achieved. The convention was formally adopted and opened for signature at the Diplomatic Conference of Plenipotentiaries in Kumamoto, Japan, on 10 October 2013, it entered into force on 16 August 2017, and its first Conference of the Parties meets in September 2017 in Geneva.

The Minamata Convention follows and builds on the Basel, Rotterdam and Stockholm conventions. It sets out the same basic substantive obligations for all countries, while providing some targeted differentiation and flexibility in specific substantive provisions, as well as provisions to mobilize financial resources by all, within their capabilities, for implementation in developing countries. Together with the Basel, Rotterdam and Stockholm conventions, it forms a comprehensive global regime for the sound management of chemicals and hazardous wastes.

The Minamata Convention is a 21st century response to the catastrophic pollution in Minamata, Japan, where industrial releases of methyl mercury caused the epidemic known as the Minamata disease in the 1950s and onwards. By naming the convention 'Minamata Convention', the name Minamata will not only be associated with a problem, but also with a solution. It is both an impressive and stimulating proof of how successful multilateralism can be to solve global problems and challenges. I would like to thank wholeheartedly all those who have contributed to that success.



INTRODUCTION

In 2001, the Governing Council of the United Nations Environment Programme[1] (UNEP) invited the Executive Director of UNEP to undertake a global assessment of mercury and its compounds, including information on the chemistry and health effects, sources, long-range transport, and prevention and control technologies relating to mercury. In 2003, the Governing Council considered this assessment and found that there was sufficient evidence of significant global adverse impacts from mercury and its compounds to warrant further international action to reduce the risks to human health and the environment from the release of mercury and its compounds to the environment. Governments were urged to adopt goals for the reduction of mercury emissions and releases and UNEP initiated technical assistance and capacity building activities to meet these goals.

Mercury is recognized as a substance producing significant adverse neurological and other health effects, with particular concerns expressed about its harmful effects on infants and unborn children. The global transport of mercury in the environment was a key reason for taking the decision that global action to address the problem of mercury pollution was required. A mercury programme to address these concerns was thus established and was further strengthened by governments in decisions of the Governing Council in 2005 and in 2007. In the decision of 2007, the Governing Council concluded that the options of enhanced voluntary measures and new or existing international legal instruments would be reviewed and assessed in order to make progress in addressing the mercury issue.

In 2009, following extensive consideration of the issue, the Governing Council agreed that voluntary actions had not been sufficient to address the concerns on mercury, and decided on the need for further action on mercury, including the preparation of a global legally binding instrument. An intergovernmental negotiating committee to prepare a global legally binding instrument on mercury was therefore established, to commence its work in 2010 and conclude its negotiations prior to the twenty-seventh session of the Governing Council in 2013. The committee was provided with a detailed mandate setting out specific issues to be covered in the text of the instrument, as well as a number of other elements to be taken into account while negotiating the text.

In January 2013, the intergovernmental negotiating committee concluded its fifth session by agreeing on the text of the Minamata Convention on Mercury. The text was adopted by the Conference of Plenipotentiaries on 10 October 2013 in Japan and was opened for signature for one year until 9 October 2014. During this period, it was signed by 127 states and one regional economic integration organization, bringing to 128 the total number of signatories.

The Conference of Plenipotentiaries also mandated the intergovernmental negotiating committee to meet during the interim period preceding the opening of the first meeting of the Conference of the Parties to the Convention to facilitate the rapid entry into force of the Convention and its effective implementation upon entry into force. Two sessions of the committee were held, in November 2014 in Bangkok, Thailand and in March 2016 at the Dead Sea in Jordan.

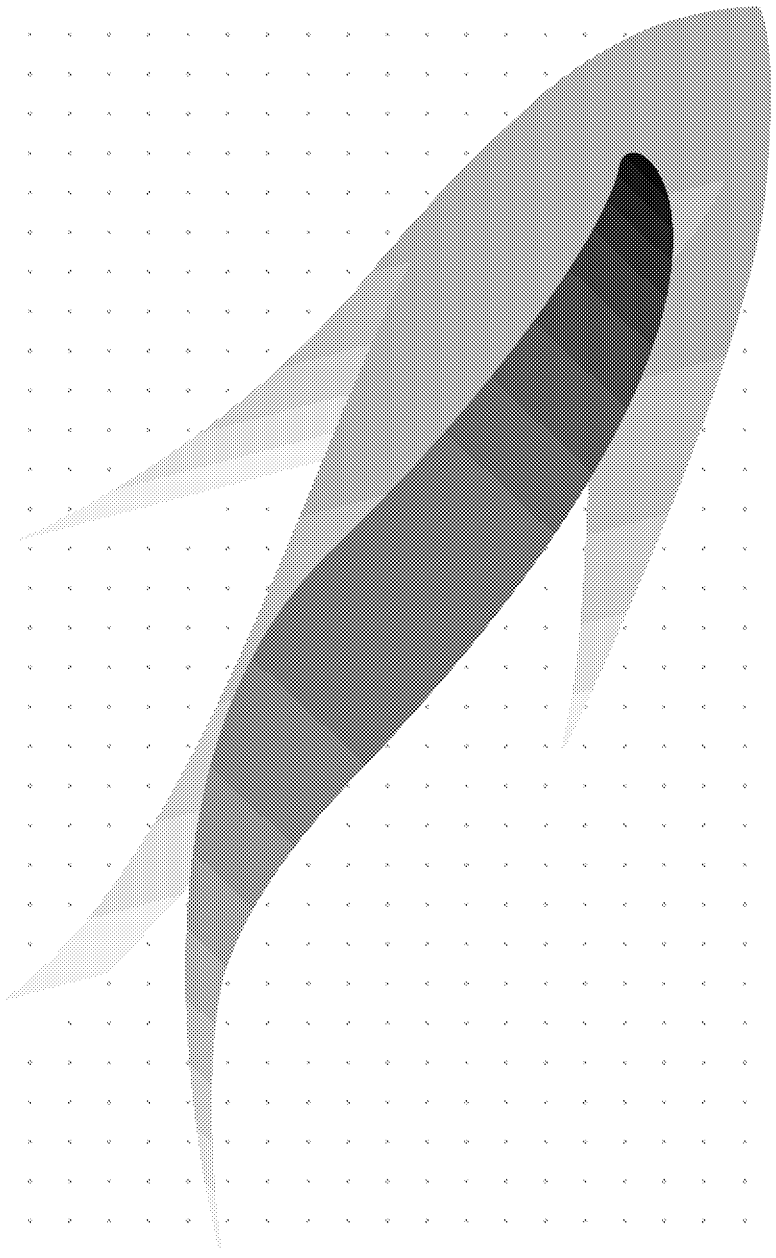
The objective of the Convention is to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds and it sets out a range of measures to meet that objective. These include measures to control the supply and trade of mercury, including setting limitations on specific sources of mercury such as

[1] As of February 2013, the designation of the Governing Council of UNEP has been changed to the United Nations Environment Assembly.

primary mining, and to control mercury-added products and manufacturing processes in which mercury or mercury compounds are used, as well as artisanal and small scale gold mining. The text of the Convention includes separate articles on emissions and releases of mercury, with controls directed at reducing levels of mercury while allowing flexibility to accommodate national development plans. In addition, it contains measures on the environmentally sound interim storage of mercury and on mercury wastes, as well as contaminated sites. Provision is made in the text for financial and technical support to developing countries and countries with economies in transition, and a financial mechanism for the provision of adequate, predictable and timely financial resources is defined.

The Minamata Convention provides that it shall enter into force on the ninetieth day after the date of deposit of the fiftieth instrument of ratification, acceptance, approval or accession. That milestone was reached on 18 May 2017, allowing the Convention to enter into force on 16 August 2017 and the holding of the first meeting of its Conference of the Parties from 24 to 29 September 2017 in Geneva, Switzerland.

It is expected that coordinated implementation of the obligations of the Convention will lead to an overall reduction in mercury levels in the environment over time, thus meeting the objective of the Convention to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.



MINAMATA CONVENTION ON MERCURY

The Parties to this Convention,

Recognizing that mercury is a chemical of global concern owing to its long-range atmospheric transport, its persistence in the environment once anthropogenically introduced, its ability to bioaccumulate in ecosystems and its significant negative effects on human health and the environment,

Recalling decision 25/5 of 20 February 2009 of the Governing Council of the United Nations Environment Programme to initiate international action to manage mercury in an efficient, effective and coherent manner,

Recalling paragraph 221 of the outcome document of the United Nations Conference on Sustainable Development "The future we want", which called for a successful outcome of the negotiations on a global legally binding instrument on mercury to address the risks to human health and the environment,

Recalling the United Nations Conference on Sustainable Development's reaffirmation of the principles of the Rio Declaration on Environment and Development, including, inter alia, common but differentiated responsibilities, and acknowledging States' respective circumstances and capabilities and the need for global action,

Aware of the health concerns, especially in developing countries, resulting from exposure to mercury of vulnerable populations, especially women, children, and, through them, future generations,

Noting the particular vulnerabilities of Arctic ecosystems and indigenous communities because of the biomagnification of mercury and contamination of traditional foods, and concerned about indigenous communities more generally with respect to the effects of mercury,

Recognizing the substantial lessons of Minamata Disease, in particular the serious health and environmental effects resulting from the mercury pollution, and the need to ensure proper management of mercury and the prevention of such events in the future,

Stressing the importance of financial, technical, technological, and capacity-building support, particularly for developing countries, and

countries with economies in transition, in order to strengthen national capabilities for the management of mercury and to promote the effective implementation of the Convention,

Recognizing also the activities of the World Health Organization in the protection of human health related to mercury and the roles of relevant multilateral environmental agreements, especially the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade,

Recognizing that this Convention and other international agreements in the field of the environment and trade are mutually supportive,

Emphasizing that nothing in this Convention is intended to affect the rights and obligations of any Party deriving from any existing international agreement,

Understanding that the above recital is not intended to create a hierarchy between this Convention and other international instruments,

Noting that nothing in this Convention prevents a Party from taking additional domestic measures consistent with the provisions of this Convention in an effort to protect human health and the environment from exposure to mercury in accordance with that Party's other obligations under applicable international law,

Have agreed as follows:

Article 1
Objective

The objective of this Convention is to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.

Article 2
Definitions

For the purposes of this Convention:

(a) "Artisanal and small-scale gold mining" means gold mining conducted by individual miners or small enterprises with limited capital investment and production;

(b) "Best available techniques" means those techniques that are the most effective to prevent and, where that is not practicable, to reduce emissions and releases of mercury to air, water and land and the impact of such emissions and releases on the environment as a whole, taking into account economic and technical considerations for a given Party or a given facility within the territory of that Party. In this context:

(i) "Best" means most effective in achieving a high general level of protection of the environment as a whole;

(ii) "Available" techniques means, in respect of a given Party and a given facility within the territory of that Party, those techniques developed on a scale that allows implementation in a relevant industrial sector under economically and technically viable conditions, taking into consideration the costs and benefits, whether or not those techniques are used or developed within the territory of that Party, provided that they are accessible to the operator of the facility as determined by that Party; and

(iii) "Techniques" means technologies used, operational practices and the ways in which installations are designed, built, maintained, operated and decommissioned;

(c) "Best environmental practices" means the application of the most appropriate combination of environmental control measures and strategies;

(d) "Mercury" means elemental mercury (Hg(0), CAS No. 7439-97-6);

(e) "Mercury compound" means any substance consisting of atoms of mercury and one or more atoms of other chemical elements that can be separated into different components only by chemical reactions;

(f) "Mercury-added product" means a product or product component that contains mercury or a mercury compound that was intentionally added;

(g) "Party" means a State or regional economic integration organization that has consented to be bound by this Convention and for which the Convention is in force;

(h) "Parties present and voting" means Parties present and casting an affirmative or negative vote at a meeting of the Parties;

(i) "Primary mercury mining" means mining in which the principal material sought is mercury;

(j) "Regional economic integration organization" means an organization constituted by sovereign States of a given region to which its member States have transferred competence in respect of matters governed by this Convention and which has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve or accede to this Convention; and

(k) "Use allowed" means any use by a Party of mercury or mercury compounds consistent with this Convention, including, but not limited to, uses consistent with Articles 3, 4, 5, 6 and 7.

Article 3
Mercury supply sources and trade

1. For the purposes of this Article:

(a) References to "mercury" include mixtures of mercury with other substances, including alloys of mercury, with a mercury concentration of at least 95 per cent by weight; and

(b) "Mercury compounds" means mercury (I) chloride (known also as calomel), mercury (II) oxide, mercury (II) sulphate, mercury (II) nitrate, cinnabar and mercury sulphide.

2. The provisions of this Article shall not apply to:

(a) Quantities of mercury or mercury compounds to be used for laboratory-scale research or as a reference standard; or

(b) Naturally occurring trace quantities of mercury or mercury compounds present in such products as non-mercury metals, ores, or mineral products, including coal, or products derived from these materials, and unintentional trace quantities in chemical products; or

(c) Mercury-added products.

3. Each Party shall not allow primary mercury mining that was not being conducted within its territory at the date of entry into force of the Convention for it.

4. Each Party shall only allow primary mercury mining that was being conducted within its territory at the date of entry into force of the Convention for it for a period of up to fifteen years after that date. During this period, mercury from such mining shall only be used in manufacturing of mercury-added products in accordance with Article 4, in manufacturing processes in accordance with Article 5, or be disposed in accordance with Article 11, using operations which do not lead to recovery, recycling, reclamation, direct re-use or alternative uses.

5. Each Party shall:

(a) Endeavour to identify individual stocks of mercury or mercury compounds exceeding 50 metric tons, as well as sources of mercury supply generating stocks exceeding 10 metric tons per year, that are located within its territory;

(b) Take measures to ensure that, where the Party determines that excess mercury from the decommissioning of chlor-alkali facilities is available, such mercury is disposed of in accordance with the guidelines for environmentally sound management referred to in paragraph 3 (a) of Article 11, using operations that do not lead to recovery, recycling, reclamation, direct re-use or alternative uses.

6. Each Party shall not allow the export of mercury except:

(a) To a Party that has provided the exporting Party with its written consent, and only for the purpose of:

(i) A use allowed to the importing Party under this Convention; or

(ii) Environmentally sound interim storage as set out in Article 10; or

(b) To a non-Party that has provided the exporting Party with its written consent, including certification demonstrating that:

(i) The non-Party has measures in place to ensure the protection of human health and the environment and to ensure its compliance with the provisions of Articles 10 and 11; and

(ii) Such mercury will be used only for a use allowed to a Party under this Convention or for environmentally sound interim storage as set out in Article 10.

7. An exporting Party may rely on a general notification to the Secretariat by the importing Party or non-Party as the written consent required by paragraph 6. Such general notification shall set out any terms and conditions under which the importing Party or non-Party provides its consent. The notification may be revoked at any time by that Party or non-Party. The Secretariat shall keep a public register of all such notifications.

8. Each Party shall not allow the import of mercury from a non-Party to whom it will provide its written consent unless the non-Party has provided certification that the mercury is not from sources identified as not allowed under paragraph 3 or paragraph 5 (b).

9. A Party that submits a general notification of consent under paragraph 7 may decide not to apply paragraph 8, provided that it maintains comprehensive restrictions on the export of mercury and has domestic measures in place to ensure that imported mercury is managed in an environmentally sound manner. The Party shall provide a notification of such decision to the Secretariat, including information describing its export restrictions and domestic regulatory measures, as well as information on the quantities and countries of origin of mercury imported from non-Parties. The Secretariat shall maintain a public register of all such notifications. The Implementation and Compliance Committee shall review and evaluate any such notifications and supporting information in accordance with Article 15 and may make recommendations, as appropriate, to the Conference of the Parties.

10. The procedure set out in paragraph 9 shall be available until the conclusion of the second meeting of the Conference of the Parties. After that time, it shall cease to be available, unless the Conference of the Parties decides otherwise by simple majority of the Parties present and voting, except with respect to a Party that has provided a notification under paragraph 9 before the end of the second meeting of the Conference of the Parties.

11. Each Party shall include in its reports submitted pursuant to Article 21 information showing that the requirements of this Article have been met.

12. The Conference of the Parties shall at its first meeting provide further guidance in regard to this Article, particularly in regard to paragraphs 5 (a), 6 and 8, and shall develop and adopt the required content of the certification referred to in paragraphs 6 (b) and 8.

13. The Conference of the Parties shall evaluate whether the trade in specific mercury compounds compromises the objective of this Convention and consider whether specific mercury compounds should, by their listing in an additional annex adopted in accordance with Article 27, be made subject to paragraphs 6 and 8.

Article 4
Mercury-added products

1. Each Party shall not allow, by taking appropriate measures, the manufacture, import or export of mercury-added products listed in Part I of Annex A after the phase-out date specified for those products, except where an exclusion is specified in Annex A or the Party has a registered exemption pursuant to Article 6.

2. A Party may, as an alternative to paragraph 1, indicate at the time of ratification or upon entry into force of an amendment to Annex A for it, that it will implement different measures or strategies to address products listed in Part I of Annex A. A Party may only choose this alternative if it can demonstrate that it has already reduced to a de minimis level the manufacture, import, and export of the large majority of the products listed in Part I of Annex A and that it has implemented measures or strategies to reduce the use of mercury in additional products not listed in

Part I of Annex A at the time it notifies the Secretariat of its decision to use this alternative. In addition, a Party choosing this alternative shall:

(a) Report at the first opportunity to the Conference of the Parties a description of the measures or strategies implemented, including a quantification of the reductions achieved;

(b) Implement measures or strategies to reduce the use of mercury in any products listed in Part I of Annex A for which a de minimis value has not yet been obtained;

(c) Consider additional measures to achieve further reductions; and

(d) Not be eligible to claim exemptions pursuant to Article 6 for any product category for which this alternative is chosen.

No later than five years after the date of entry into force of the Convention, the Conference of the Parties shall, as part of the review process under paragraph 8, review the progress and the effectiveness of the measures taken under this paragraph.

3. Each Party shall take measures for the mercury-added products listed in Part II of Annex A in accordance with the provisions set out therein.

4. The Secretariat shall, on the basis of information provided by Parties, collect and maintain information on mercury-added products and their alternatives, and shall make such information publicly available. The Secretariat shall also make publicly available any other relevant information submitted by Parties.

5. Each Party shall take measures to prevent the incorporation into assembled products of mercury-added products the manufacture, import and export of which are not allowed for it under this Article.

6. Each Party shall discourage the manufacture and the distribution in commerce of mercury-added products not covered by any known use of mercury-added products prior to the date of entry into force of the Convention for it, unless an assessment of the risks and benefits of the product demonstrates environmental or human health benefits. A Party shall provide to the Secretariat, as appropriate, information on any such product, including any information on the environmental and human

health risks and benefits of the product. The Secretariat shall make such information publicly available.

7. Any Party may submit a proposal to the Secretariat for listing a mercury-added product in Annex A, which shall include information related to the availability, technical and economic feasibility and environmental and health risks and benefits of the non-mercury alternatives to the product, taking into account information pursuant to paragraph 4.

8. No later than five years after the date of entry into force of the Convention, the Conference of the Parties shall review Annex A and may consider amendments to that Annex in accordance with Article 27.

9. In reviewing Annex A pursuant to paragraph 8, the Conference of the Parties shall take into account at least:

(a) Any proposal submitted under paragraph 7;

(b) The information made available pursuant to paragraph 4; and

(c) The availability to the Parties of mercury-free alternatives that are technically and economically feasible, taking into account the environmental and human health risks and benefits.

Article 5

Manufacturing processes in which mercury or mercury compounds are used

1. For the purposes of this Article and Annex B, manufacturing processes in which mercury or mercury compounds are used shall not include processes using mercury-added products, processes for manufacturing mercury-added products or processes that process mercury-containing waste.

2. Each Party shall not allow, by taking appropriate measures, the use of mercury or mercury compounds in the manufacturing processes listed in Part I of Annex B after the phase-out date specified in that Annex for the individual processes, except where the Party has a registered exemption pursuant to Article 6.

3. Each Party shall take measures to restrict the use of mercury or mercury compounds in the processes listed in Part II of Annex B in accordance with the provisions set out therein.

4. The Secretariat shall, on the basis of information provided by Parties, collect and maintain information on processes that use mercury or mercury compounds and their alternatives, and shall make such information publicly available. Other relevant information may also be submitted by Parties and shall be made publicly available by the Secretariat.

5. Each Party with one or more facilities that use mercury or mercury compounds in the manufacturing processes listed in Annex B shall:

(a) Take measures to address emissions and releases of mercury or mercury compounds from those facilities;

(b) Include in its reports submitted pursuant to Article 21 information on the measures taken pursuant to this paragraph; and

(c) Endeavour to identify facilities within its territory that use mercury or mercury compounds for processes listed in Annex B and submit to the Secretariat, no later than three years after the date of entry into force of the Convention for it, information on the number and types of such facilities and the estimated annual amount of mercury or mercury compounds used in those facilities. The Secretariat shall make such information publicly available.

6. Each Party shall not allow the use of mercury or mercury compounds in a facility that did not exist prior to the date of entry into force of the Convention for it using the manufacturing processes listed in Annex B. No exemptions shall apply to such facilities.

7. Each Party shall discourage the development of any facility using any other manufacturing process in which mercury or mercury compounds are intentionally used that did not exist prior to the date of entry into force of the Convention, except where the Party can demonstrate to the satisfaction of the Conference of the Parties that the manufacturing process provides significant environmental and health benefits and that there are no technically and economically feasible mercury-free alternatives available providing such benefits.

8. Parties are encouraged to exchange information on relevant new technological developments, economically and technically feasible mercury-free alternatives, and possible measures and techniques to reduce and where feasible to eliminate the use of mercury and mercury compounds in, and emissions and releases of mercury and mercury compounds from, the manufacturing processes listed in Annex B.

9. Any Party may submit a proposal to amend Annex B in order to list a manufacturing process in which mercury or mercury compounds are used. It shall include information related to the availability, technical and economic feasibility and environmental and health risks and benefits of the non-mercury alternatives to the process.

10. No later than five years after the date of entry into force of the Convention, the Conference of the Parties shall review Annex B and may consider amendments to that Annex in accordance with Article 27.

11. In any review of Annex B pursuant to paragraph 10, the Conference of the Parties shall take into account at least:

(a) Any proposal submitted under paragraph 9;

(b) The information made available under paragraph 4; and

(c) The availability for the Parties of mercury-free alternatives which are technically and economically feasible taking into account the environmental and health risks and benefits.

Article 6
Exemptions available to a Party upon request

1. Any State or regional economic integration organization may register for one or more exemptions from the phase-out dates listed in Annex A and Annex B, hereafter referred to as an "exemption", by notifying the Secretariat in writing:

(a) On becoming a Party to this Convention; or

(b) In the case of any mercury-added product that is added by an amendment to Annex A or any manufacturing process in which mercury is used that is added by an amendment to Annex B, no later than the date

upon which the applicable amendment enters into force for the Party.

Any such registration shall be accompanied by a statement explaining the Party's need for the exemption.

2. An exemption can be registered either for a category listed in Annex A or B or for a sub-category identified by any State or regional economic integration organization.

3. Each Party that has one or more exemptions shall be identified in a register. The Secretariat shall establish and maintain the register and make it available to the public.

4. The register shall include:

(a) A list of the Parties that have one or more exemptions;

(b) The exemption or exemptions registered for each Party; and

(c) The expiration date of each exemption.

5. Unless a shorter period is indicated in the register by a Party, all exemptions pursuant to paragraph 1 shall expire five years after the relevant phase-out date listed in Annex A or B.

6. The Conference of the Parties may, at the request of a Party, decide to extend an exemption for five years unless the Party requests a shorter period. In making its decision, the Conference of the Parties shall take due account of:

(a) A report from the Party justifying the need to extend the exemption and outlining activities undertaken and planned to eliminate the need for the exemption as soon as feasible;

(b) Available information, including in respect of the availability of alternative products and processes that are free of mercury or that involve the consumption of less mercury than the exempt use; and

(c) Activities planned or under way to provide environmentally sound storage of mercury and disposal of mercury wastes.

An exemption may only be extended once per product per phase-out date.

7. A Party may at any time withdraw an exemption upon written notification to the Secretariat. The withdrawal of an exemption shall take effect on the date specified in the notification.

8. Notwithstanding paragraph 1, no State or regional economic integration organization may register for an exemption after five years after the phase-out date for the relevant product or process listed in Annex A or B, unless one or more Parties remain registered for an exemption for that product or process, having received an extension pursuant to paragraph 6. In that case, a State or regional economic integration organization may, at the times set out in paragraphs 1 (a) and (b), register for an exemption for that product or process, which shall expire ten years after the relevant phase-out date.

9. No Party may have an exemption in effect at any time after 10 years after the phase-out date for a product or process listed in Annex A or B.

Article 7
Artisanal and small-scale gold mining

1. The measures in this Article and in Annex C shall apply to artisanal and small-scale gold mining and processing in which mercury amalgamation is used to extract gold from ore.

2. Each Party that has artisanal and small-scale gold mining and processing subject to this Article within its territory shall take steps to reduce, and where feasible eliminate, the use of mercury and mercury compounds in, and the emissions and releases to the environment of mercury from, such mining and processing.

3. Each Party shall notify the Secretariat if at any time the Party determines that artisanal and small-scale gold mining and processing in its territory is more than insignificant. If it so determines the Party shall:

(a) Develop and implement a national action plan in accordance with Annex C;

(b) Submit its national action plan to the Secretariat no later than three years after entry into force of the Convention for it or three years after the notification to the Secretariat, whichever is later; and

(c) Thereafter, provide a review every three years of the progress made in meeting its obligations under this Article and include such reviews in its reports submitted pursuant to Article 21.

4. Parties may cooperate with each other and with relevant intergovernmental organizations and other entities, as appropriate, to achieve the objectives of this Article. Such cooperation may include:

(a) Development of strategies to prevent the diversion of mercury or mercury compounds for use in artisanal and small-scale gold mining and processing;

(b) Education, outreach and capacity-building initiatives;

(c) Promotion of research into sustainable non-mercury alternative practices;

(d) Provision of technical and financial assistance;

(e) Partnerships to assist in the implementation of their commitments under this Article; and

(f) Use of existing information exchange mechanisms to promote knowledge, best environmental practices and alternative technologies that are environmentally, technically, socially and economically viable.

Article 8
Emissions

1. This Article concerns controlling and, where feasible, reducing emissions of mercury and mercury compounds, often expressed as "total mercury", to the atmosphere through measures to control emissions from the point sources falling within the source categories listed in Annex D.

2. For the purposes of this Article:

(a) "Emissions" means emissions of mercury or mercury compounds to the atmosphere;

(b) "Relevant source" means a source falling within one of the source categories listed in Annex D. A Party may, if it chooses, establish criteria to

identify the sources covered within a source category listed in Annex D so long as those criteria for any category include at least 75 per cent of the emissions from that category;

(c) "New source" means any relevant source within a category listed in Annex D, the construction or substantial modification of which is commenced at least one year after the date of:

(i) Entry into force of this Convention for the Party concerned; or

(ii) Entry into force for the Party concerned of an amendment to Annex D where the source becomes subject to the provisions of this Convention only by virtue of that amendment;

(d) "Substantial modification" means modification of a relevant source that results in a significant increase in emissions, excluding any change in emissions resulting from by-product recovery. It shall be a matter for the Party to decide whether a modification is substantial or not;

(e) "Existing source" means any relevant source that is not a new source;

(f) "Emission limit value" means a limit on the concentration, mass or emission rate of mercury or mercury compounds, often expressed as "total mercury", emitted from a point source.

3. A Party with relevant sources shall take measures to control emissions and may prepare a national plan setting out the measures to be taken to control emissions and its expected targets, goals and outcomes. Any plan shall be submitted to the Conference of the Parties within four years of the date of entry into force of the Convention for that Party. If a Party develops an implementation plan in accordance with Article 20, the Party may include in it the plan prepared pursuant to this paragraph.

4. For its new sources, each Party shall require the use of best available techniques and best environmental practices to control and, where feasible, reduce emissions, as soon as practicable but no later than five years after the date of entry into force of the Convention for that Party. A Party may use emission limit values that are consistent with the application of best available techniques.

5. For its existing sources, each Party shall include in any national plan, and shall implement, one or more of the following measures, taking into account its national circumstances, and the economic and technical feasibility and affordability of the measures, as soon as practicable but no more than ten years after the date of entry into force of the Convention for it:

(a) A quantified goal for controlling and, where feasible, reducing emissions from relevant sources;

(b) Emission limit values for controlling and, where feasible, reducing emissions from relevant sources;

(c) The use of best available techniques and best environmental practices to control emissions from relevant sources;

(d) A multi-pollutant control strategy that would deliver co-benefits for control of mercury emissions;

(e) Alternative measures to reduce emissions from relevant sources.

6. Parties may apply the same measures to all relevant existing sources or may adopt different measures in respect of different source categories. The objective shall be for those measures applied by a Party to achieve reasonable progress in reducing emissions over time.

7. Each Party shall establish, as soon as practicable and no later than five years after the date of entry into force of the Convention for it, and maintain thereafter, an inventory of emissions from relevant sources.

8. The Conference of the Parties shall, at its first meeting, adopt guidance on:

(a) Best available techniques and on best environmental practices, taking into account any difference between new and existing sources and the need to minimize cross-media effects; and

(b) Support for Parties in implementing the measures set out in paragraph 5, in particular in determining goals and in setting emission limit values.

9. The Conference of the Parties shall, as soon as practicable, adopt guidance on:

(a) Criteria that Parties may develop pursuant to paragraph 2 (b);

(b) The methodology for preparing inventories of emissions.

10. The Conference of the Parties shall keep under review, and update as appropriate, the guidance developed pursuant to paragraphs 8 and 9. Parties shall take the guidance into account in implementing the relevant provisions of this Article.

11. Each Party shall include information on its implementation of this Article in its reports submitted pursuant to Article 21, in particular information concerning the measures it has taken in accordance with paragraphs 4 to 7 and the effectiveness of the measures.

Article 9
Releases

1. This Article concerns controlling and, where feasible, reducing releases of mercury and mercury compounds, often expressed as "total mercury", to land and water from the relevant point sources not addressed in other provisions of this Convention.

2. For the purposes of this Article:

(a) "Releases" means releases of mercury or mercury compounds to land or water;

(b) "Relevant source" means any significant anthropogenic point source of release as identified by a Party that is not addressed in other provisions of this Convention;

(c) "New source" means any relevant source, the construction or substantial modification of which is commenced at least one year after the date of entry into force of this Convention for the Party concerned;

(d) "Substantial modification" means modification of a relevant source that results in a significant increase in releases, excluding any change in releases resulting from by-product recovery. It shall be a matter for the Party to decide whether a modification is substantial or not;

(e) "Existing source" means any relevant source that is not a new source;

(f) "Release limit value" means a limit on the concentration or mass of mercury or mercury compounds, often expressed as "total mercury", released from a point source.

3. Each Party shall, no later than three years after the date of entry into force of the Convention for it and on a regular basis thereafter, identify the relevant point source categories.

4. A Party with relevant sources shall take measures to control releases and may prepare a national plan setting out the measures to be taken to control releases and its expected targets, goals and outcomes. Any plan shall be submitted to the Conference of the Parties within four years of the date of entry into force of the Convention for that Party. If a Party develops an implementation plan in accordance with Article 20, the Party may include in it the plan prepared pursuant to this paragraph.

5. The measures shall include one or more of the following, as appropriate:

(a) Release limit values to control and, where feasible, reduce releases from relevant sources;

(b) The use of best available techniques and best environmental practices to control releases from relevant sources;

(c) A multi-pollutant control strategy that would deliver co-benefits for control of mercury releases;

(d) Alternative measures to reduce releases from relevant sources.

6. Each Party shall establish, as soon as practicable and no later than five years after the date of entry into force of the Convention for it, and maintain thereafter, an inventory of releases from relevant sources.

7. The Conference of the Parties shall, as soon as practicable, adopt guidance on:

(a) Best available techniques and on best environmental practices, taking into account any difference between new and existing sources and the need to minimize cross-media effects;

(b) The methodology for preparing inventories of releases.

8. Each Party shall include information on its implementation of this Article in its reports submitted pursuant to Article 21, in particular information concerning the measures it has taken in accordance with paragraphs 3 to 6 and the effectiveness of the measures.

Article 10

Environmentally sound interim storage of mercury, other than waste mercury

1. This Article shall apply to the interim storage of mercury and mercury compounds as defined in Article 3 that do not fall within the meaning of the definition of mercury wastes set out in Article 11.

2. Each Party shall take measures to ensure that the interim storage of such mercury and mercury compounds intended for a use allowed to a Party under this Convention is undertaken in an environmentally sound manner, taking into account any guidelines, and in accordance with any requirements, adopted pursuant to paragraph 3.

3. The Conference of the Parties shall adopt guidelines on the environmentally sound interim storage of such mercury and mercury compounds, taking into account any relevant guidelines developed under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal and other relevant guidance. The Conference of the Parties may adopt requirements for interim storage in an additional annex to this Convention in accordance with Article 27.

4. Parties shall cooperate, as appropriate, with each other and with relevant intergovernmental organizations and other entities, to enhance capacity-building for the environmentally sound interim storage of such mercury and mercury compounds.

Article 11

Mercury wastes

1. The relevant definitions of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal shall apply to wastes covered under this Convention for Parties to the Basel Convention. Parties to this Convention that are not Parties to the Basel

Convention shall use those definitions as guidance as applied to wastes covered under this Convention.

2. For the purposes of this Convention, mercury wastes means substances or objects:

(a) Consisting of mercury or mercury compounds;

(b) Containing mercury or mercury compounds; or

(c) Contaminated with mercury or mercury compounds,

in a quantity above the relevant thresholds defined by the Conference of the Parties, in collaboration with the relevant bodies of the Basel Convention in a harmonized manner, that are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law or this Convention. This definition excludes overburden, waste rock and tailings from mining, except from primary mercury mining, unless they contain mercury or mercury compounds above thresholds defined by the Conference of the Parties.

3. Each Party shall take appropriate measures so that mercury waste is:

(a) Managed in an environmentally sound manner, taking into account the guidelines developed under the Basel Convention and in accordance with requirements that the Conference of the Parties shall adopt in an additional annex in accordance with Article 27. In developing requirements, the Conference of the Parties shall take into account Parties' waste management regulations and programmes;

(b) Only recovered, recycled, reclaimed or directly re-used for a use allowed to a Party under this Convention or for environmentally sound disposal pursuant to paragraph 3 (a);

(c) For Parties to the Basel Convention, not transported across international boundaries except for the purpose of environmentally sound disposal in conformity with this Article and with that Convention. In circumstances where the Basel Convention does not apply to transport across international boundaries, a Party shall allow such transport only after taking into account relevant international rules, standards, and guidelines.

4. The Conference of the Parties shall seek to cooperate closely with the relevant bodies of the Basel Convention in the review and update, as appropriate, of the guidelines referred to in paragraph 3 (a).

5. Parties are encouraged to cooperate with each other and with relevant intergovernmental organizations and other entities, as appropriate, to develop and maintain global, regional and national capacity for the management of mercury wastes in an environmentally sound manner.

Article 12
Contaminated sites

1. Each Party shall endeavour to develop appropriate strategies for identifying and assessing sites contaminated by mercury or mercury compounds.

2. Any actions to reduce the risks posed by such sites shall be performed in an environmentally sound manner incorporating, where appropriate, an assessment of the risks to human health and the environment from the mercury or mercury compounds they contain.

3. The Conference of the Parties shall adopt guidance on managing contaminated sites that may include methods and approaches for:

(a) Site identification and characterization;

(b) Engaging the public;

(c) Human health and environmental risk assessments;

(d) Options for managing the risks posed by contaminated sites;

(e) Evaluation of benefits and costs; and

(f) Validation of outcomes.

4. Parties are encouraged to cooperate in developing strategies and implementing activities for identifying, assessing, prioritizing, managing and, as appropriate, remediating contaminated sites.

Article 13
Financial resources and mechanism

1. Each Party undertakes to provide, within its capabilities, resources in respect of those national activities that are intended to implement this Convention, in accordance with its national policies, priorities, plans and programmes. Such resources may include domestic funding through relevant policies, development strategies and national budgets, and bilateral and multilateral funding, as well as private sector involvement.

2. The overall effectiveness of implementation of this Convention by developing country Parties will be related to the effective implementation of this Article.

3. Multilateral, regional and bilateral sources of financial and technical assistance, as well as capacity-building and technology transfer, are encouraged, on an urgent basis, to enhance and increase their activities on mercury in support of developing country Parties in the implementation of this Convention relating to financial resources, technical assistance and technology transfer.

4. The Parties, in their actions with regard to funding, shall take full account of the specific needs and special circumstances of Parties that are small island developing States or least developed countries.

5. A Mechanism for the provision of adequate, predictable, and timely financial resources is hereby defined. The Mechanism is to support developing country Parties and Parties with economies in transition in implementing their obligations under this Convention.

6. The Mechanism shall include:

(a) The Global Environment Facility Trust Fund; and

(b) A specific international Programme to support capacity-building and technical assistance.

7. The Global Environment Facility Trust Fund shall provide new, predictable, adequate and timely financial resources to meet costs in support of implementation of this Convention as agreed by the Conference of the Parties. For the purposes of this Convention, the Global

Environment Facility Trust Fund shall be operated under the guidance of and be accountable to the Conference of the Parties. The Conference of the Parties shall provide guidance on overall strategies, policies, programme priorities and eligibility for access to and utilization of financial resources. In addition, the Conference of the Parties shall provide guidance on an indicative list of categories of activities that could receive support from the Global Environment Facility Trust Fund. The Global Environment Facility Trust Fund shall provide resources to meet the agreed incremental costs of global environmental benefits and the agreed full costs of some enabling activities.

8. In providing resources for an activity, the Global Environment Facility Trust Fund should take into account the potential mercury reductions of a proposed activity relative to its costs.

9. For the purposes of this Convention, the Programme referred to in paragraph 6 (b) will be operated under the guidance of and be accountable to the Conference of the Parties. The Conference of the Parties shall, at its first meeting, decide on the hosting institution for the Programme, which shall be an existing entity, and provide guidance to it, including on its duration. All Parties and other relevant stakeholders are invited to provide financial resources to the Programme, on a voluntary basis.

10. The Conference of the Parties and the entities comprising the Mechanism shall agree upon, at the first meeting of the Conference of the Parties, arrangements to give effect to the above paragraphs.

11. The Conference of the Parties shall review, no later than at its third meeting, and thereafter on a regular basis, the level of funding, the guidance provided by the Conference of the Parties to the entities entrusted to operationalize the Mechanism established under this Article and their effectiveness, and their ability to address the changing needs of developing country Parties and Parties with economies in transition. It shall, based on such review, take appropriate action to improve the effectiveness of the Mechanism.

12. All Parties, within their capabilities, are invited to contribute to the Mechanism. The Mechanism shall encourage the provision of resources from other sources, including the private sector, and shall seek to leverage such resources for the activities it supports.

Article 14

Capacity-building, technical assistance and technology transfer

1. Parties shall cooperate to provide, within their respective capabilities, timely and appropriate capacity-building and technical assistance to developing country Parties, in particular Parties that are least developed countries or small island developing States, and Parties with economies in transition, to assist them in implementing their obligations under this Convention.

2. Capacity-building and technical assistance pursuant to paragraph 1 and Article 13 may be delivered through regional, subregional and national arrangements, including existing regional and subregional centres, through other multilateral and bilateral means, and through partnerships, including partnerships involving the private sector. Cooperation and coordination with other multilateral environmental agreements in the field of chemicals and wastes should be sought to increase the effectiveness of technical assistance and its delivery.

3. Developed country Parties and other Parties within their capabilities shall promote and facilitate, supported by the private sector and other relevant stakeholders as appropriate, development, transfer and diffusion of, and access to, up-to-date environmentally sound alternative technologies to developing country Parties, in particular the least developed countries and small island developing States, and Parties with economies in transition, to strengthen their capacity to effectively implement this Convention.

4. The Conference of the Parties shall, by its second meeting and thereafter on a regular basis, and taking into account submissions and reports from Parties including those as provided for in Article 21 and information provided by other stakeholders:

(a) Consider information on existing initiatives and progress made in relation to alternative technologies;

(b) Consider the needs of Parties, particularly developing country Parties, for alternative technologies; and

(c) Identify challenges experienced by Parties, particularly developing country Parties, in technology transfer.

5. The Conference of the Parties shall make recommendations on how capacity-building, technical assistance and technology transfer could be further enhanced under this Article.

Article 15
Implementation and Compliance Committee

1. A mechanism, including a Committee as a subsidiary body of the Conference of the Parties, is hereby established to promote implementation of, and review compliance with, all provisions of this Convention. The mechanism, including the Committee, shall be facilitative in nature and shall pay particular attention to the respective national capabilities and circumstances of Parties.

2. The Committee shall promote implementation of, and review compliance with, all provisions of this Convention. The Committee shall examine both individual and systemic issues of implementation and compliance and make recommendations, as appropriate, to the Conference of the Parties.

3. The Committee shall consist of 15 members, nominated by Parties and elected by the Conference of the Parties, with due consideration to equitable geographical representation based on the five regions of the United Nations; the first members shall be elected at the first meeting of the Conference of the Parties and thereafter in accordance with the rules of procedure approved by the Conference of the Parties pursuant to paragraph 5; the members of the Committee shall have competence in a field relevant to this Convention and reflect an appropriate balance of expertise.

4. The Committee may consider issues on the basis of:

(a) Written submissions from any Party with respect to its own compliance;

(b) National reports in accordance with Article 21; and

(c) Requests from the Conference of the Parties.

5. The Committee shall elaborate its rules of procedure, which shall be subject to approval by the second meeting of the Conference of the Parties; the Conference of the Parties may adopt further terms of reference for the Committee.

6. The Committee shall make every effort to adopt its recommendations by consensus. If all efforts at consensus have been exhausted and no consensus is reached, such recommendations shall as a last resort be adopted by a three-fourths majority vote of the members present and voting, based on a quorum of two-thirds of the members.

Article 16
Health aspects

1. Parties are encouraged to:

(a) Promote the development and implementation of strategies and programmes to identify and protect populations at risk, particularly vulnerable populations, and which may include adopting science-based health guidelines relating to the exposure to mercury and mercury compounds, setting targets for mercury exposure reduction, where appropriate, and public education, with the participation of public health and other involved sectors;

(b) Promote the development and implementation of science-based educational and preventive programmes on occupational exposure to mercury and mercury compounds;

(c) Promote appropriate health-care services for prevention, treatment and care for populations affected by the exposure to mercury or mercury compounds; and

(d) Establish and strengthen, as appropriate, the institutional and health professional capacities for the prevention, diagnosis, treatment and monitoring of health risks related to the exposure to mercury and mercury compounds.

2. The Conference of the Parties, in considering health-related issues or activities, should:

(a) Consult and collaborate with the World Health Organization, the International Labour Organization and other relevant intergovernmental organizations, as appropriate; and

(b) Promote cooperation and exchange of information with the World Health Organization, the International Labour Organization and other relevant intergovernmental organizations, as appropriate.

Article 17
Information exchange

1. Each Party shall facilitate the exchange of:

(a) Scientific, technical, economic and legal information concerning mercury and mercury compounds, including toxicological, ecotoxicological and safety information;

(b) Information on the reduction or elimination of the production, use, trade, emissions and releases of mercury and mercury compounds;

(c) Information on technically and economically viable alternatives to:

(i) Mercury-added products;

(ii) Manufacturing processes in which mercury or mercury compounds are used; and

(iii) Activities and processes that emit or release mercury or mercury compounds;

including information on the health and environmental risks and economic and social costs and benefits of such alternatives; and

(d) Epidemiological information concerning health impacts associated with exposure to mercury and mercury compounds, in close cooperation with the World Health Organization and other relevant organizations, as appropriate.

2. Parties may exchange the information referred to in paragraph 1 directly, through the Secretariat, or in cooperation with other relevant organizations, including the secretariats of chemicals and wastes conventions, as appropriate.

3. The Secretariat shall facilitate cooperation in the exchange of information referred to in this Article, as well as with relevant organizations, including the secretariats of multilateral environmental agreements and other international initiatives. In addition to information from Parties, this information shall include information from intergovernmental and non-governmental organizations with expertise in the area of mercury, and from national and international institutions with such expertise.

4. Each Party shall designate a national focal point for the exchange of information under this Convention, including with regard to the consent of importing Parties under Article 3.

5. For the purposes of this Convention, information on the health and safety of humans and the environment shall not be regarded as confidential. Parties that exchange other information pursuant to this Convention shall protect any confidential information as mutually agreed.

Article 18

Public information, awareness and education

1. Each Party shall, within its capabilities, promote and facilitate:

   (a) Provision to the public of available information on:

      (i) The health and environmental effects of mercury and mercury compounds;

      (ii) Alternatives to mercury and mercury compounds;

      (iii) The topics identified in paragraph 1 of Article 17;

      (iv) The results of its research, development and monitoring activities under Article 19; and

      (v) Activities to meet its obligations under this Convention;

   (b) Education, training and public awareness related to the effects of exposure to mercury and mercury compounds on human health

and the environment in collaboration with relevant intergovernmental and non-governmental organizations and vulnerable populations, as appropriate.

2. Each Party shall use existing mechanisms or give consideration to the development of mechanisms, such as pollutant release and transfer registers where applicable, for the collection and dissemination of information on estimates of its annual quantities of mercury and mercury compounds that are emitted, released or disposed of through human activities.

Article 19
Research, development and monitoring

1. Parties shall endeavour to cooperate to develop and improve, taking into account their respective circumstances and capabilities:

(a) Inventories of use, consumption, and anthropogenic emissions to air and releases to water and land of mercury and mercury compounds;

(b) Modelling and geographically representative monitoring of levels of mercury and mercury compounds in vulnerable populations and in environmental media, including biotic media such as fish, marine mammals, sea turtles and birds, as well as collaboration in the collection and exchange of relevant and appropriate samples;

(c) Assessments of the impact of mercury and mercury compounds on human health and the environment, in addition to social, economic and cultural impacts, particularly in respect of vulnerable populations;

(d) Harmonized methodologies for the activities undertaken under subparagraphs (a), (b) and (c);

(e) Information on the environmental cycle, transport (including long-range transport and deposition), transformation and fate of mercury and mercury compounds in a range of ecosystems, taking appropriate account of the distinction between anthropogenic and natural emissions and releases of mercury and of remobilization of mercury from historic deposition;

(f) Information on commerce and trade in mercury and mercury compounds and mercury-added products; and

(g) Information and research on the technical and economic availability of mercury-free products and processes and on best available techniques and best environmental practices to reduce and monitor emissions and releases of mercury and mercury compounds.

2. Parties should, where appropriate, build on existing monitoring networks and research programmes in undertaking the activities identified in paragraph 1.

Article 20
Implementation plans

1. Each Party may, following an initial assessment, develop and execute an implementation plan, taking into account its domestic circumstances, for meeting the obligations under this Convention. Any such plan should be transmitted to the Secretariat as soon as it has been developed.

2. Each Party may review and update its implementation plan, taking into account its domestic circumstances and referring to guidance from the Conference of the Parties and other relevant guidance.

3. Parties should, in undertaking work in paragraphs 1 and 2, consult national stakeholders to facilitate the development, implementation, review and updating of their implementation plans.

4. Parties may also coordinate on regional plans to facilitate implementation of this Convention.

Article 21
Reporting

1. Each Party shall report to the Conference of the Parties, through the Secretariat, on the measures it has taken to implement the provisions of this Convention and on the effectiveness of such measures and the possible challenges in meeting the objectives of the Convention.

2. Each Party shall include in its reporting the information as called for in Articles 3, 5, 7, 8 and 9 of this Convention.

3. The Conference of the Parties shall, at its first meeting, decide upon the timing and format of the reporting to be followed by the Parties, taking into account the desirability of coordinating reporting with other relevant chemicals and wastes conventions.

Article 22
Effectiveness evaluation

1. The Conference of the Parties shall evaluate the effectiveness of this Convention, beginning no later than six years after the date of entry into force of the Convention and periodically thereafter at intervals to be decided by it.

2. To facilitate the evaluation, the Conference of the Parties shall, at its first meeting, initiate the establishment of arrangements for providing itself with comparable monitoring data on the presence and movement of mercury and mercury compounds in the environment as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations.

3. The evaluation shall be conducted on the basis of available scientific, environmental, technical, financial and economic information, including:

(a) Reports and other monitoring information provided to the Conference of the Parties pursuant to paragraph 2;

(b) Reports submitted pursuant to Article 21;

(c) Information and recommendations provided pursuant to Article 15; and

(d) Reports and other relevant information on the operation of the financial assistance, technology transfer and capacity-building arrangements put in place under this Convention.

Article 23
Conference of the Parties

1. A Conference of the Parties is hereby established.

2. The first meeting of the Conference of the Parties shall be convened by the Executive Director of the United Nations Environment Programme no later than one year after the date of entry into force of this Convention. Thereafter, ordinary meetings of the Conference of the Parties shall be held at regular intervals to be decided by the Conference.

3. Extraordinary meetings of the Conference of the Parties shall be held at such other times as may be deemed necessary by the Conference, or at the written request of any Party, provided that, within six months of the request being communicated to the Parties by the Secretariat, it is supported by at least one third of the Parties.

4. The Conference of the Parties shall by consensus agree upon and adopt at its first meeting rules of procedure and financial rules for itself and any of its subsidiary bodies, as well as financial provisions governing the functioning of the Secretariat.

5. The Conference of the Parties shall keep under continuous review and evaluation the implementation of this Convention. It shall perform the functions assigned to it by this Convention and, to that end, shall:

(a) Establish such subsidiary bodies as it considers necessary for the implementation of this Convention;

(b) Cooperate, where appropriate, with competent international organizations and intergovernmental and non-governmental bodies;

(c) Regularly review all information made available to it and to the Secretariat pursuant to Article 21;

(d) Consider any recommendations submitted to it by the Implementation and Compliance Committee;

(e) Consider and undertake any additional action that may be required for the achievement of the objectives of this Convention; and

(f) Review Annexes A and B pursuant to Article 4 and Article 5.

6. The United Nations, its specialized agencies and the International Atomic Energy Agency, as well as any State not a Party to this Convention, may be represented at meetings of the Conference of the Parties as observers. Any body or agency, whether national or international,

governmental or non-governmental, that is qualified in matters covered by this Convention and has informed the Secretariat of its wish to be represented at a meeting of the Conference of the Parties as an observer may be admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the Conference of the Parties.

Article 24
Secretariat

1. A Secretariat is hereby established.

2. The functions of the Secretariat shall be:

(a) To make arrangements for meetings of the Conference of the Parties and its subsidiary bodies and to provide them with services as required;

(b) To facilitate assistance to Parties, particularly developing country Parties and Parties with economies in transition, on request, in the implementation of this Convention;

(c) To coordinate, as appropriate, with the secretariats of relevant international bodies, particularly other chemicals and waste conventions;

(d) To assist Parties in the exchange of information related to the implementation of this Convention;

(e) To prepare and make available to the Parties periodic reports based on information received pursuant to Articles 15 and 21 and other available information;

(f) To enter, under the overall guidance of the Conference of the Parties, into such administrative and contractual arrangements as may be required for the effective discharge of its functions; and

(g) To perform the other secretariat functions specified in this Convention and such other functions as may be determined by the Conference of the Parties.

3. The secretariat functions for this Convention shall be performed by the Executive Director of the United Nations Environment Programme, unless the Conference of the Parties decides, by a three-fourths majority of the Parties present and voting, to entrust the secretariat functions to one or more other international organizations.

4. The Conference of the Parties, in consultation with appropriate international bodies, may provide for enhanced cooperation and coordination between the Secretariat and the secretariats of other chemicals and wastes conventions. The Conference of the Parties, in consultation with appropriate international bodies, may provide further guidance on this matter.

Article 25
Settlement of disputes

1. Parties shall seek to settle any dispute between them concerning the interpretation or application of this Convention through negotiation or other peaceful means of their own choice.

2. When ratifying, accepting, approving or acceding to this Convention, or at any time thereafter, a Party that is not a regional economic integration organization may declare in a written instrument submitted to the Depositary that, with regard to any dispute concerning the interpretation or application of this Convention, it recognizes one or both of the following means of dispute settlement as compulsory in relation to any Party accepting the same obligation:

(a) Arbitration in accordance with the procedure set out in Part I of Annex E;

(b) Submission of the dispute to the International Court of Justice.

3. A Party that is a regional economic integration organization may make a declaration with like effect in relation to arbitration in accordance with paragraph 2.

4. A declaration made pursuant to paragraph 2 or 3 shall remain in force until it expires in accordance with its terms or until three months after written notice of its revocation has been deposited with the Depositary.

5. The expiry of a declaration, a notice of revocation or a new declaration shall in no way affect proceedings pending before an arbitral tribunal or the International Court of Justice, unless the parties to the dispute otherwise agree.

6. If the parties to a dispute have not accepted the same means of dispute settlement pursuant to paragraph 2 or 3, and if they have not been able to settle their dispute through the means mentioned in paragraph 1 within twelve months following notification by one Party to another that a dispute exists between them, the dispute shall be submitted to a conciliation commission at the request of any party to the dispute. The procedure set out in Part II of Annex E shall apply to conciliation under this Article.

Article 26
Amendments to the Convention

1. Amendments to this Convention may be proposed by any Party.

2. Amendments to this Convention shall be adopted at a meeting of the Conference of the Parties. The text of any proposed amendment shall be communicated to the Parties by the Secretariat at least six months before the meeting at which it is proposed for adoption. The Secretariat shall also communicate the proposed amendment to the signatories to this Convention and, for information, to the Depositary.

3. The Parties shall make every effort to reach agreement on any proposed amendment to this Convention by consensus. If all efforts at consensus have been exhausted, and no agreement reached, the amendment shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting.

4. An adopted amendment shall be communicated by the Depositary to all Parties for ratification, acceptance or approval.

5. Ratification, acceptance or approval of an amendment shall be notified to the Depositary in writing. An amendment adopted in accordance with paragraph 3 shall enter into force for the Parties having consented to be bound by it on the ninetieth day after the date of deposit of instruments of ratification, acceptance or approval by at least three-fourths of the Parties

that were Parties at the time at which the amendment was adopted. Thereafter, the amendment shall enter into force for any other Party on the ninetieth day after the date on which that Party deposits its instrument of ratification, acceptance or approval of the amendment.

Article 27
Adoption and amendment of annexes

1. Annexes to this Convention shall form an integral part thereof and, unless expressly provided otherwise, a reference to this Convention constitutes at the same time a reference to any annexes thereto.

2. Any additional annexes adopted after the entry into force of this Convention shall be restricted to procedural, scientific, technical or administrative matters.

3. The following procedure shall apply to the proposal, adoption and entry into force of additional annexes to this Convention:

(a) Additional annexes shall be proposed and adopted according to the procedure laid down in paragraphs 1–3 of Article 26;

(b) Any Party that is unable to accept an additional annex shall so notify the Depositary, in writing, within one year from the date of communication by the Depositary of the adoption of such annex. The Depositary shall without delay notify all Parties of any such notification received. A Party may at any time notify the Depositary, in writing, that it withdraws a previous notification of non-acceptance in respect of an additional annex, and the annex shall thereupon enter into force for that Party subject to subparagraph (c); and

(c) On the expiry of one year from the date of the communication by the Depositary of the adoption of an additional annex, the annex shall enter into force for all Parties that have not submitted a notification of non-acceptance in accordance with the provisions of subparagraph (b).

4. The proposal, adoption and entry into force of amendments to annexes to this Convention shall be subject to the same procedures as for the proposal, adoption and entry into force of additional annexes to the Convention, except that an amendment to an annex shall not enter into

force with regard to any Party that has made a declaration with regard to amendment of annexes in accordance with paragraph 5 of Article 30, in which case any such amendment shall enter into force for such a Party on the ninetieth day after the date it has deposited with the Depositary its instrument of ratification, acceptance, approval or accession with respect to such amendment.

5. If an additional annex or an amendment to an annex is related to an amendment to this Convention, the additional annex or amendment shall not enter into force until such time as the amendment to the Convention enters into force.

Article 28
Right to vote

1. Each Party to this Convention shall have one vote, except as provided for in paragraph 2.

2. A regional economic integration organization, on matters within its competence, shall exercise its right to vote with a number of votes equal to the number of its member States that are Parties to this Convention. Such an organization shall not exercise its right to vote if any of its member States exercises its right to vote, and vice versa.

Article 29
Signature

This Convention shall be opened for signature at Kumamoto, Japan, by all States and regional economic integration organizations on 10 and 11 October 2013, and thereafter at the United Nations Headquarters in New York until 9 October 2014.

Article 30
Ratification, acceptance, approval or accession

1. This Convention shall be subject to ratification, acceptance or approval by States and by regional economic integration organizations. It shall be open for accession by States and by regional economic integration

organizations from the day after the date on which the Convention is closed for signature. Instruments of ratification, acceptance, approval or accession shall be deposited with the Depositary.

2. Any regional economic integration organization that becomes a Party to this Convention without any of its member States being a Party shall be bound by all the obligations under the Convention. In the case of such organizations, one or more of whose member States is a Party to this Convention, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under the Convention. In such cases, the organization and the member States shall not be entitled to exercise rights under the Convention concurrently.

3. In its instrument of ratification, acceptance, approval or accession, a regional economic integration organization shall declare the extent of its competence in respect of the matters governed by this Convention. Any such organization shall also inform the Depositary, who shall in turn inform the Parties, of any relevant modification of the extent of its competence.

4. Each State or regional economic integration organization is encouraged to transmit to the Secretariat at the time of its ratification, acceptance, approval or accession of the Convention information on its measures to implement the Convention.

5. In its instrument of ratification, acceptance, approval or accession, any Party may declare that, with regard to it, any amendment to an annex shall enter into force only upon the deposit of its instrument of ratification, acceptance, approval or accession with respect thereto.

Article 31
Entry into force

1. This Convention shall enter into force on the ninetieth day after the date of deposit of the fiftieth instrument of ratification, acceptance, approval or accession.

2. For each State or regional economic integration organization that ratifies, accepts or approves this Convention or accedes thereto after the deposit of the fiftieth instrument of ratification, acceptance, approval or accession, the Convention shall enter into force on the ninetieth day after the date of deposit by such State or regional economic integration organization of its instrument of ratification, acceptance, approval or accession.

3. For the purposes of paragraphs 1 and 2, any instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by member States of that organization.

Article 32
Reservations

No reservations may be made to this Convention.

Article 33
Withdrawal

1. At any time after three years from the date on which this Convention has entered into force for a Party, that Party may withdraw from the Convention by giving written notification to the Depositary.

2. Any such withdrawal shall take effect upon expiry of one year from the date of receipt by the Depositary of the notification of withdrawal, or on such later date as may be specified in the notification of withdrawal.

Article 34
Depositary

The Secretary-General of the United Nations shall be the Depositary of this Convention.

Article 35
Authentic texts

The original of this Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Depositary.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have signed this Convention.

Done at Kumamoto, Japan, on this tenth day of October, two thousand and thirteen.

ANNEXES

Annex A

Mercury-added products

The following products are excluded from this Annex:

(a) Products essential for civil protection and military uses;

(b) Products for research, calibration of instrumentation, for use as reference standard;

(c) Where no feasible mercury-free alternative for replacement is available, switches and relays, cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays, and measuring devices;

(d) Products used in traditional or religious practices; and

(e) Vaccines containing thiomersal as preservatives.

Part I: Products subject to Article 4, paragraph 1

Mercury-added products	**Date after which the manufacture, import or export of the product shall not be allowed (phase-out date)**
Batteries, except for button zinc silver oxide batteries with a mercury content < 2% and button zinc air batteries with a mercury content < 2%	2020
Switches and relays, except very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch or relay	2020
Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner	2020

Linear fluorescent lamps (LFLs) for general lighting purposes: (a) Triband phosphor < 60 watts with a mercury content exceeding 5 mg per lamp; (b) Halophosphate phosphor ≤ 40 watts with a mercury content exceeding 10 mg per lamp	2020
High pressure mercury vapour lamps (HPMV) for general lighting purposes	2020
Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: (a) short length (≤ 500 mm) with mercury content exceeding 3.5 mg per lamp (b) medium length (> 500 mm and ≤ 1 500 mm) with mercury content exceeding 5 mg per lamp (c) long length (> 1 500 mm) with mercury content exceeding 13 mg per lamp	2020
Cosmetics (with mercury content above 1ppm), including skin lightening soaps and creams, and not including eye area cosmetics where mercury is used as a preservative and no effective and safe substitute preservatives are available[1/]	2020
Pesticides, biocides and topical antiseptics	2020
The following non-electronic measuring devices except non-electronic measuring devices installed in large-scale equipment or those used for high precision measurement, where no suitable mercury-free alternative is available: (a) barometers; (b) hygrometers; (c) manometers; (d) thermometers; (e) sphygmomanometers.	2020

[1/] The intention is not to cover cosmetics, soaps or creams with trace contaminants of mercury.

Part II: Products subject to Article 4, paragraph 3

Mercury-added products	Provisions
Dental amalgam	Measures to be taken by a Party to phase down the use of dental amalgam shall take into account the Party's domestic circumstances and relevant international guidance and shall include two or more of the measures from the following list: (i) Setting national objectives aiming at dental caries prevention and health promotion, thereby minimizing the need for dental restoration; (ii) Setting national objectives aiming at minimizing its use; (iii) Promoting the use of cost-effective and clinically effective mercury-free alternatives for dental restoration; (iv) Promoting research and development of quality mercury-free materials for dental restoration; (v) Encouraging representative professional organizations and dental schools to educate and train dental professionals and students on the use of mercury-free dental restoration alternatives and on promoting best management practices; (vi) Discouraging insurance policies and programmes that favour dental amalgam use over mercury-free dental restoration; (vii) Encouraging insurance policies and programmes that favour the use of quality alternatives to dental amalgam for dental restoration; (viii) Restricting the use of dental amalgam to its encapsulated form; (ix) Promoting the use of best environmental practices in dental facilities to reduce releases of mercury and mercury compounds to water and land.

Annex B

Manufacturing processes in which mercury or mercury compounds are used

Part I: Processes subject to Article 5, paragraph 2

Manufacturing processes using mercury or mercury compounds	Phase-out date
Chlor-alkali production	2025
Acetaldehyde production in which mercury or mercury compounds are used as a catalyst	2018

Part II: Processes subject to Article 5, paragraph 3

Mercury using process	Provisions
Vinyl chloride monomer production	Measures to be taken by the Parties shall include but not be limited to: (i) Reduce the use of mercury in terms of per unit production by 50 per cent by the year 2020 against 2010 use; (ii) Promoting measures to reduce the reliance on mercury from primary mining; (iii) Taking measures to reduce emissions and releases of mercury to the environment; (iv) Supporting research and development in respect of mercury-free catalysts and processes; (v) Not allowing the use of mercury five years after the Conference of the Parties has established that mercury-free catalysts based on existing processes have become technically and economically feasible; (vi) Reporting to the Conference of the Parties on its efforts to develop and/or identify alternatives and phase out mercury use in accordance with Article 21.

Sodium or Potassium Methylate or Ethylate	Measures to be taken by the Parties shall include but not be limited to: (i) Measures to reduce the use of mercury aiming at the phase out of this use as fast as possible and within 10 years of the entry into force of the Convention; (ii) Reduce emissions and releases in terms of per unit production by 50 per cent by 2020 compared to 2010; (iii) Prohibiting the use of fresh mercury from primary mining; (iv) Supporting research and development in respect of mercury-free processes; (v) Not allowing the use of mercury five years after the Conference of the Parties has established that mercury-free processes have become technically and economically feasible; (vi) Reporting to the Conference of the Parties on its efforts to develop and/or identify alternatives and phase out mercury use in accordance with Article 21.
Production of polyurethane using mercury containing catalysts	Measures to be taken by the Parties shall include but not be limited to: (i) Taking measures to reduce the use of mercury, aiming at the phase out of this use as fast as possible, within 10 years of the entry into force of the Convention; (ii) Taking measures to reduce the reliance on mercury from primary mercury mining; (iii) Taking measures to reduce emissions and releases of mercury to the environment; (iii) Encouraging research and development in respect of mercury-free catalysts and processes; (iv) Reporting to the Conference of the Parties on its efforts to develop and/or identify alternatives and phase out mercury use in accordance with Article 21. Paragraph 6 of Article 5 shall not apply to this manufacturing process.

Annex C

Artisanal and small-scale gold mining

National action plans

1. Each Party that is subject to the provisions of paragraph 3 of Article 7 shall include in its national action plan:

(a) National objectives and reduction targets;

(b) Actions to eliminate:

(i) Whole ore amalgamation;

(ii) Open burning of amalgam or processed amalgam;

(iii) Burning of amalgam in residential areas; and

(iv) Cyanide leaching in sediment, ore or tailings to which mercury has been added without first removing the mercury;

(c) Steps to facilitate the formalization or regulation of the artisanal and small-scale gold mining sector;

(d) Baseline estimates of the quantities of mercury used and the practices employed in artisanal and small-scale gold mining and processing within its territory;

(e) Strategies for promoting the reduction of emissions and releases of, and exposure to, mercury in artisanal and small-scale gold mining and processing, including mercury-free methods;

(f) Strategies for managing trade and preventing the diversion of mercury and mercury compounds from both foreign and domestic sources to use in artisanal and small scale gold mining and processing;

(g) Strategies for involving stakeholders in the implementation and continuing development of the national action plan;

(h) A public health strategy on the exposure of artisanal and small-scale gold miners and their communities to mercury. Such a strategy

should include, inter alia, the gathering of health data, training for health-care workers and awareness-raising through health facilities;

(i) Strategies to prevent the exposure of vulnerable populations, particularly children and women of child-bearing age, especially pregnant women, to mercury used in artisanal and small-scale gold mining;

(j) Strategies for providing information to artisanal and small-scale gold miners and affected communities; and

(k) A schedule for the implementation of the national action plan.

2. Each Party may include in its national action plan additional strategies to achieve its objectives, including the use or introduction of standards for mercury-free artisanal and small-scale gold mining and market-based mechanisms or marketing tools.

Annex D

List of point sources of emissions of mercury and mercury compounds to the atmosphere

Point source category:

Coal-fired power plants;

Coal-fired industrial boilers;

Smelting and roasting processes used in the production of non-ferrous metals; [1/]

Waste incineration facilities;

Cement clinker production facilities.

[1/] For the purpose of this Annex, "non-ferrous metals" refers to lead, zinc, copper and industrial gold.

Annex E

Arbitration and conciliation procedures

Part I: Arbitration procedure

The arbitration procedure for purposes of paragraph 2 (a) of Article 25 of this Convention shall be as follows:

Article 1

1. A Party may initiate recourse to arbitration in accordance with Article 25 of this Convention by written notification addressed to the other party or parties to the dispute. The notification shall be accompanied by a statement of claim, together with any supporting documents. Such notification shall state the subject matter of arbitration and include, in particular, the Articles of this Convention the interpretation or application of which are at issue.

2. The claimant party shall notify the Secretariat that it is referring a dispute to arbitration pursuant to Article 25 of this Convention. The notification shall be accompanied by the written notification of the claimant party, the statement of claim, and the supporting documents referred to in paragraph 1 above. The Secretariat shall forward the information thus received to all Parties.

Article 2

1. If a dispute is referred to arbitration in accordance with Article 1 above, an arbitral tribunal shall be established. It shall consist of three members.

2. Each party to the dispute shall appoint an arbitrator, and the two arbitrators so appointed shall designate by agreement the third arbitrator, who shall be the President of the tribunal. In disputes between more than two parties, parties in the same interest shall appoint one arbitrator jointly by agreement. The President of the tribunal shall not be a national of any of the parties to the dispute, nor have his or her usual place of residence in the territory of any of these parties, nor be employed by any of them, nor have dealt with the case in any other capacity.

3. Any vacancy shall be filled in the manner prescribed for the initial appointment.

Article 3

1. If one of the parties to the dispute does not appoint an arbitrator within two months of the date on which the respondent party receives the notification of the arbitration, the other party may inform the Secretary-General of the United Nations, who shall make the designation within a further two-month period.

2. If the President of the arbitral tribunal has not been designated within two months of the date of the appointment of the second arbitrator, the Secretary-General of the United Nations shall, at the request of a party, designate the President within a further two-month period.

Article 4

The arbitral tribunal shall render its decisions in accordance with the provisions of this Convention and international law.

Article 5

Unless the parties to the dispute otherwise agree, the arbitral tribunal shall determine its own rules of procedure.

Article 6

The arbitral tribunal may, at the request of one of the parties to the dispute, recommend essential interim measures of protection.

Article 7

The parties to the dispute shall facilitate the work of the arbitral tribunal and, in particular, using all means at their disposal, shall:

(a) Provide it with all relevant documents, information and facilities; and

(b) Enable it, when necessary, to call witnesses or experts and receive their evidence.

Article 8

The parties to the dispute and the arbitrators are under an obligation to protect the confidentiality of any information or documents that they receive in confidence during the proceedings of the arbitral tribunal.

Article 9

Unless the arbitral tribunal determines otherwise because of the particular circumstances of the case, the costs of the tribunal shall be borne by the parties to the dispute in equal shares. The tribunal shall keep a record of all its costs and shall furnish a final statement thereof to the parties.

Article 10

A Party that has an interest of a legal nature in the subject matter of the dispute that may be affected by the decision may intervene in the proceedings with the consent of the arbitral tribunal.

Article 11

The arbitral tribunal may hear and determine counterclaims arising directly out of the subject matter of the dispute.

Article 12

Decisions of the arbitral tribunal on both procedure and substance shall be taken by a majority vote of its members.

Article 13

1. If one of the parties to the dispute does not appear before the arbitral tribunal or fails to defend its case, the other party may request the tribunal to continue the proceedings and to make its decision. Absence of a party or a failure of a party to defend its case shall not constitute a bar to the proceedings.

2. Before rendering its final decision, the arbitral tribunal must satisfy itself that the claim is well founded in fact and law.

Article 14

The arbitral tribunal shall render its final decision within five months of the date on which it is fully constituted, unless it finds it necessary to extend the time limit for a period that should not exceed five more months.

Article 15

The final decision of the arbitral tribunal shall be confined to the subject matter of the dispute and shall state the reasons on which it is based. It shall contain the names of the members who have participated and the date of the final decision. Any member of the tribunal may attach a separate or dissenting opinion to the final decision.

Article 16

The final decision shall be binding on the parties to the dispute. The interpretation of this Convention given by the final decision shall also be binding upon a Party intervening under Article 10 above insofar as it relates to matters in respect of which that Party intervened. The final decision shall be without appeal unless the parties to the dispute have agreed in advance to an appellate procedure.

Article 17

Any disagreement that may arise between those bound by the final decision in accordance with Article 16 above, as regards the interpretation or manner of implementation of that final decision, may be submitted by any of them for decision to the arbitral tribunal that rendered it.

Part II: Conciliation procedure

The conciliation procedure for purposes of paragraph 6 of Article 25 of this Convention shall be as follows:

Article 1

A request by a party to a dispute to establish a conciliation commission pursuant to paragraph 6 of Article 25 of this Convention shall be addressed in writing to the Secretariat, with a copy to the other party or parties to the dispute. The Secretariat shall forthwith inform all Parties accordingly.

Article 2

1. The conciliation commission shall, unless the parties to the dispute otherwise agree, comprise three members, one appointed by each party concerned and a President chosen jointly by those members.

2. In disputes between more than two parties, parties in the same interest shall appoint their member of the commission jointly by agreement.

Article 3

If any appointment by the parties to the dispute is not made within two months of the date of receipt by the Secretariat of the written request referred to in Article 1 above, the Secretary-General of the United Nations shall, upon request by any party, make such appointment within a further two-month period.

Article 4

If the President of the conciliation commission has not been chosen within two months of the appointment of the second member of the commission, the Secretary-General of the United Nations shall, upon request by any party to the dispute, designate the President within a further two-month period.

Article 5

The conciliation commission shall assist the parties to the dispute in an independent and impartial manner in their attempt to reach an amicable resolution.

Article 6

1. The conciliation commission may conduct the conciliation proceedings in such a manner as it considers appropriate, taking fully into account the circumstances of the case and the views the parties to the dispute may express, including any request for a swift resolution. It may adopt its own rules of procedure as necessary, unless the parties otherwise agree.

2. The conciliation commission may, at any time during the proceedings, make proposals or recommendations for a resolution of the dispute.

Article 7

The parties to the dispute shall cooperate with the conciliation commission. In particular, they shall endeavour to comply with requests by the commission to submit written materials, provide evidence and attend meetings. The parties and the members of the conciliation commission are under an obligation to protect the confidentiality of any information or documents they receive in confidence during the proceedings of the commission.

Article 8

The conciliation commission shall take its decisions by a majority vote of its members.

Article 9

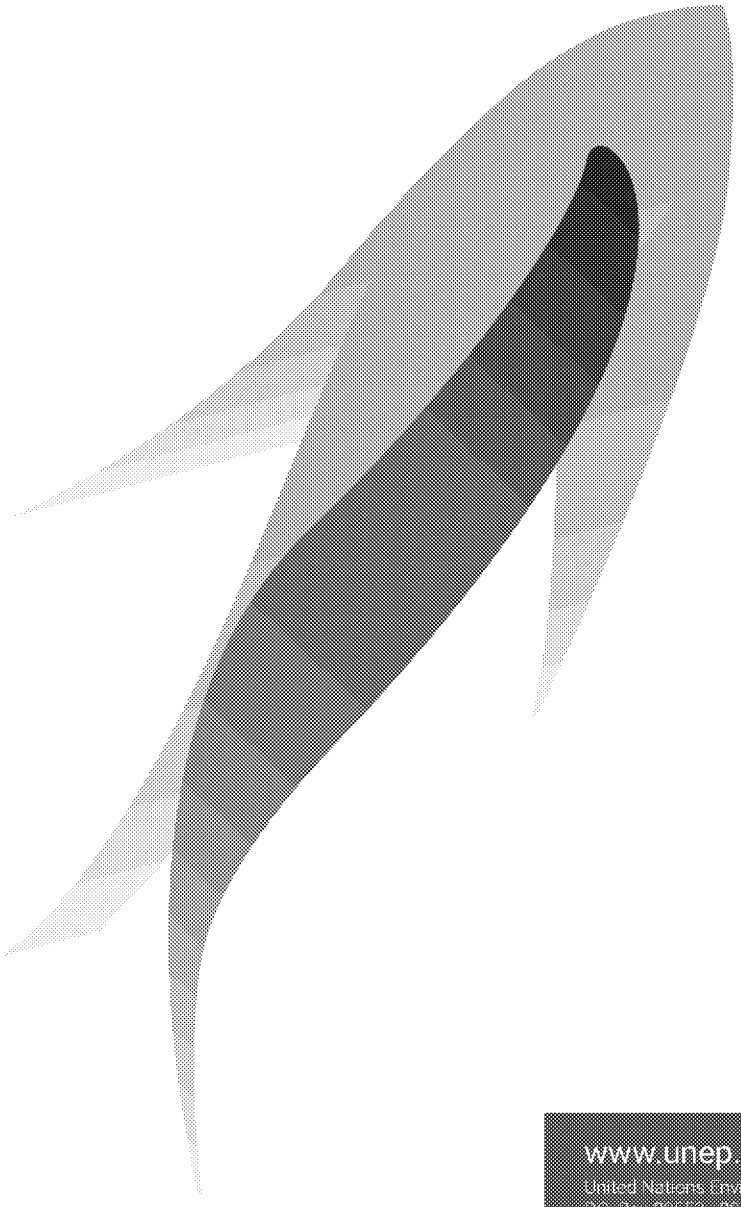
Unless the dispute has already been resolved, the conciliation commission shall render a report with recommendations for resolution of the dispute no later than twelve months of being fully constituted, which the parties to the dispute shall consider in good faith.

Article 10

Any disagreement as to whether the conciliation commission has competence to consider a matter referred to it shall be decided by the commission.

Article 11

The costs of the conciliation commission shall be borne by the parties to the dispute in equal shares, unless they agree otherwise. The commission shall keep a record of all its costs and shall furnish a final statement thereof to the parties.



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UN environment
United Nations Environment Programme

UNITED NATIONS DECLARATION ON THE RIGHTS OF INDIGENOUS PEOPLES

United Nations

UNITED NATIONS DECLARATION ON THE RIGHTS OF INDIGENOUS PEOPLES

United Nations

Resolution adopted by the General Assembly on 13 September 2007

[without reference to a Main Committee (A/61/L.67 and Add.1)]

61/295. United Nations Declaration on the Rights of Indigenous Peoples

The General Assembly,

Taking note of the recommendation of the Human Rights Council contained in its resolution 1/2 of 29 June 2006[1], by which the Council adopted the text of the United Nations Declaration on the Rights of Indigenous Peoples,

Recalling its resolution 61/178 of 20 December 2006, by which it decided to defer consideration of and action on the Declaration to allow time for further consultations thereon, and also decided to conclude its consideration before the end of the sixty-first session of the General Assembly,

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1 See Official Records of the General Assembly, Sixty-first Session, Supplement No. 53 (A/61/53), part one, chap. II, sect. A.

Adopts the United Nations Declaration on the Rights of Indigenous Peoples as contained in the annex to the present resolution.

107th plenary meeting
13 September 2007

Annex

United Nations Declaration on the Rights of Indigenous Peoples

The General Assembly,

Guided by the purposes and principles of the Charter of the United Nations, and good faith in the fulfilment of the obligations assumed by States in accordance with the Charter,

Affirming that indigenous peoples are equal to all other peoples, while recognizing the right of all peoples to be different, to consider themselves different, and to be respected as such,

Affirming also that all peoples contribute to the diversity and richness of civilizations and cultures, which constitute the common heritage of humankind,

Affirming further that all doctrines, policies and practices based on or advocating superiority of peoples or individuals on the basis of national origin or racial, religious, ethnic or cultural differences are racist, scientifically false, legally invalid, morally condemnable and socially unjust,

Reaffirming that indigenous peoples, in the exercise of their rights, should be free from discrimination of any kind,

Concerned that indigenous peoples have suffered from historic injustices as a result of, inter alia, their colonization and dispossession of their lands, territories and resources, thus preventing them from exercising, in particular, their right to development in accordance with their own needs and interests,

Recognizing the urgent need to respect and promote the inherent rights of indigenous peoples which derive from their political, economic and social structures and from their cultures, spiritual traditions, histories and philosophies, especially their rights to their lands, territories and resources,

Recognizing also the urgent need to respect and promote the rights of indigenous peoples

affirmed in treaties, agreements and other constructive arrangements with States,

Welcoming the fact that indigenous peoples are organizing themselves for political, economic, social and cultural enhancement and in order to bring to an end all forms of discrimination and oppression wherever they occur,

Convinced that control by indigenous peoples over developments affecting them and their lands, territories and resources will enable them to maintain and strengthen their institutions, cultures and traditions, and to promote their development in accordance with their aspirations and needs,

Recognizing that respect for indigenous knowledge, cultures and traditional practices contributes to sustainable and equitable development and proper management of the environment,

Emphasizing the contribution of the demilitarization of the lands and territories of indigenous peoples to peace, economic and social progress and development, understanding and friendly relations among nations and peoples of the world,

Recognizing in particular the right of indigenous families and communities to retain shared responsibility for the upbringing, training, education and well-being of their children, consistent with the rights of the child,

Considering that the rights affirmed in treaties, agreements and other constructive arrangements between States and indigenous peoples are, in some situations, matters of international concern, interest, responsibility and character,

Considering also that treaties, agreements and other constructive arrangements, and the relationship they represent, are the basis for a strengthened partnership between indigenous peoples and States,

Acknowledging that the Charter of the United Nations, the International Covenant on Economic, Social and Cultural Rights[2] and the International Covenant on Civil and Political Rights,[2] as well as the Vienna Declaration and Programme of Action,[3] affirm the fundamental importance of the right to self-determination of all peoples, by

2 See resolution 2200 A (XXI), annex.

3 A/CONF.157/24 (Part I), chap. III.

virtue of which they freely determine their political status and freely pursue their economic, social and cultural development,

Bearing in mind that nothing in this Declaration may be used to deny any peoples their right to self-determination, exercised in conformity with international law,

Convinced that the recognition of the rights of indigenous peoples in this Declaration will enhance harmonious and cooperative relations between the State and indigenous peoples, based on principles of justice, democracy, respect for human rights, non-discrimination and good faith,

Encouraging States to comply with and effectively implement all their obligations as they apply to indigenous peoples under international instruments, in particular those related to human rights, in consultation and cooperation with the peoples concerned,

Emphasizing that the United Nations has an important and continuing role to play in promoting and protecting the rights of indigenous peoples,

Believing that this Declaration is a further important step forward for the recognition, promotion and protection of the rights and freedoms of indigenous peoples and in the development of relevant activities of the United Nations system in this field,

Recognizing and reaffirming that indigenous individuals are entitled without discrimination to all human rights recognized in international law, and that indigenous peoples possess collective rights which are indispensable for their existence, well-being and integral development as peoples,

Recognizing that the situation of indigenous peoples varies from region to region and from country to country and that the significance of national and regional particularities and various historical and cultural backgrounds should be taken into consideration,

Solemnly proclaims the following United Nations Declaration on the Rights of Indigenous Peoples as a standard of achievement to be pursued in a spirit of partnership and mutual respect:

Article 1

Indigenous peoples have the right to the full enjoyment, as a collective or as individuals, of all

human rights and fundamental freedoms as recognized in the Charter of the United Nations, the Universal Declaration of Human Rights[4] and international human rights law.

Article 2

Indigenous peoples and individuals are free and equal to all other peoples and individuals and have the right to be free from any kind of discrimination, in the exercise of their rights, in particular that based on their indigenous origin or identity.

Article 3

Indigenous peoples have the right to self-determination. By virtue of that right they freely determine their political status and freely pursue their economic, social and cultural development.

Article 4

Indigenous peoples, in exercising their right to self-determination, have the right to autonomy or self-government in matters relating to their internal and local affairs, as well as ways and means for financing their autonomous functions.

4 Resolution 217 A (III).

Article 5

Indigenous peoples have the right to maintain and strengthen their distinct political, legal, economic, social and cultural institutions, while retaining their right to participate fully, if they so choose, in the political, economic, social and cultural life of the State.

Article 6

Every indigenous individual has the right to a nationality.

Article 7

1. Indigenous individuals have the rights to life, physical and mental integrity, liberty and security of person.

2. Indigenous peoples have the collective right to live in freedom, peace and security as distinct peoples and shall not be subjected to any act of genocide or any other act of violence, including forcibly removing children of the group to another group.

Article 8

1. Indigenous peoples and individuals have the right not to be subjected to forced assimilation or destruction of their culture.

2. States shall provide effective mechanisms for prevention of, and redress for:

   (a) Any action which has the aim or effect of depriving them of their integrity as distinct peoples, or of their cultural values or ethnic identities;

   (b) Any action which has the aim or effect of dispossessing them of their lands, territories or resources;

   (c) Any form of forced population transfer which has the aim or effect of violating or undermining any of their rights;

   (d) Any form of forced assimilation or integration;

   (e) Any form of propaganda designed to promote or incite racial or ethnic discrimination directed against them.

Article 9

Indigenous peoples and individuals have the right to belong to an indigenous community or nation, in accordance with the traditions and customs of the community or nation concerned. No discrimination of any kind may arise from the exercise of such a right.

Article 10

Indigenous peoples shall not be forcibly removed from their lands or territories. No relocation shall take place without the free, prior and informed consent of the indigenous peoples concerned and after agreement on just and fair compensation and, where possible, with the option of return.

Article 11

1. Indigenous peoples have the right to practise and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures, such as archaeological and historical sites, artefacts, designs, ceremonies, technologies and visual and performing arts and literature.

2. States shall provide redress through effective mechanisms, which may include restitution, developed in conjunction with indigenous peoples, with respect to their cultural, intellectual, religious and spiritual property taken without their free, prior and informed consent or in violation of their laws, traditions and customs.

Article 12

1. Indigenous peoples have the right to manifest, practise, develop and teach their spiritual and religious traditions, customs and ceremonies; the right to maintain, protect, and have access in privacy to their religious and cultural sites; the right to the use and control of their ceremonial objects; and the right to the repatriation of their human remains.

2. States shall seek to enable the access and/or repatriation of ceremonial objects and human remains in their possession through fair, transparent and effective mechanisms developed in conjunction with indigenous peoples concerned.

Article 13

1. Indigenous peoples have the right to revitalize, use, develop and transmit to future genera-

tions their histories, languages, oral traditions, philosophies, writing systems and literatures, and to designate and retain their own names for communities, places and persons.

2. States shall take effective measures to ensure that this right is protected and also to ensure that indigenous peoples can understand and be understood in political, legal and administrative proceedings, where necessary through the provision of interpretation or by other appropriate means.

Article 14

1. Indigenous peoples have the right to establish and control their educational systems and institutions providing education in their own languages, in a manner appropriate to their cultural methods of teaching and learning.

2. Indigenous individuals, particularly children, have the right to all levels and forms of education of the State without discrimination.

3. States shall, in conjunction with indigenous peoples, take effective measures, in order for indigenous individuals, particularly children, including

those living outside their communities, to have access, when possible, to an education in their own culture and provided in their own language.

Article 15

1. Indigenous peoples have the right to the dignity and diversity of their cultures, traditions, histories and aspirations which shall be appropriately reflected in education and public information.

2. States shall take effective measures, in consultation and cooperation with the indigenous peoples concerned, to combat prejudice and eliminate discrimination and to promote tolerance, understanding and good relations among indigenous peoples and all other segments of society.

Article 16

1. Indigenous peoples have the right to establish their own media in their own languages and to have access to all forms of non-indigenous media without discrimination.

2. States shall take effective measures to ensure that State-owned media duly reflect indigenous

cultural diversity. States, without prejudice to ensuring full freedom of expression, should encourage privately owned media to adequately reflect indigenous cultural diversity.

Article 17

1. Indigenous individuals and peoples have the right to enjoy fully all rights established under applicable international and domestic labour law.

2. States shall in consultation and cooperation with indigenous peoples take specific measures to protect indigenous children from economic exploitation and from performing any work that is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development, taking into account their special vulnerability and the importance of education for their empowerment.

3. Indigenous individuals have the right not to be subjected to any discriminatory conditions of labour and, inter alia, employment or salary.

Article 18

Indigenous peoples have the right to participate in decision-making in matters which would affect

their rights, through representatives chosen by themselves in accordance with their own procedures, as well as to maintain and develop their own indigenous decision-making institutions.

Article 19

States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free, prior and informed consent before adopting and implementing legislative or administrative measures that may affect them.

Article 20

1. Indigenous peoples have the right to maintain and develop their political, economic and social systems or institutions, to be secure in the enjoyment of their own means of subsistence and development, and to engage freely in all their traditional and other economic activities.

2. Indigenous peoples deprived of their means of subsistence and development are entitled to just and fair redress.

Article 21

1. Indigenous peoples have the right, without discrimination, to the improvement of their economic and social conditions, including, inter alia, in the areas of education, employment, vocational training and retraining, housing, sanitation, health and social security.

2. States shall take effective measures and, where appropriate, special measures to ensure continuing improvement of their economic and social conditions. Particular attention shall be paid to the rights and special needs of indigenous elders, women, youth, children and persons with disabilities.

Article 22

1. Particular attention shall be paid to the rights and special needs of indigenous elders, women, youth, children and persons with disabilities in the implementation of this Declaration.

2. States shall take measures, in conjunction with indigenous peoples, to ensure that indigenous women and children enjoy the full protection and guarantees against all forms of violence and discrimination.

Article 23

Indigenous peoples have the right to determine and develop priorities and strategies for exercising their right to development. In particular, indigenous peoples have the right to be actively involved in developing and determining health, housing and other economic and social programmes affecting them and, as far as possible, to administer such programmes through their own institutions.

Article 24

1. Indigenous peoples have the right to their traditional medicines and to maintain their health practices, including the conservation of their vital medicinal plants, animals and minerals. Indigenous individuals also have the right to access, without any discrimination, to all social and health services.

2. Indigenous individuals have an equal right to the enjoyment of the highest attainable standard of physical and mental health. States shall take the necessary steps with a view to achieving progressively the full realization of this right.

Article 25

Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.

Article 26

1. Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired.

2. Indigenous peoples have the right to own, use, develop and control the lands, territories and resources that they possess by reason of traditional ownership or other traditional occupation or use, as well as those which they have otherwise acquired.

3. States shall give legal recognition and protection to these lands, territories and resources. Such recognition shall be conducted with due respect to the customs, traditions and land tenure systems of the indigenous peoples concerned.

Article 27

States shall establish and implement, in conjunction with indigenous peoples concerned, a fair, independent, impartial, open and transparent process, giving due recognition to indigenous peoples' laws, traditions, customs and land tenure systems, to recognize and adjudicate the rights of indigenous peoples pertaining to their lands, territories and resources, including those which were traditionally owned or otherwise occupied or used. Indigenous peoples shall have the right to participate in this process.

Article 28

1. Indigenous peoples have the right to redress, by means that can include restitution or, when this is not possible, just, fair and equitable compensation, for the lands, territories and resources which they have traditionally owned or otherwise occupied or used, and which have been confiscated, taken, occupied, used or damaged without their free, prior and informed consent.

2. Unless otherwise freely agreed upon by the peoples concerned, compensation shall take

the form of lands, territories and resources equal in quality, size and legal status or of monetary compensation or other appropriate redress.

Article 29

1. Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. States shall establish and implement assistance programmes for indigenous peoples for such conservation and protection, without discrimination.

2. States shall take effective measures to ensure that no storage or disposal of hazardous materials shall take place in the lands or territories of indigenous peoples without their free, prior and informed consent.

3. States shall also take effective measures to ensure, as needed, that programmes for monitoring, maintaining and restoring the health of indigenous peoples, as developed and implemented by the peoples affected by such materials, are duly implemented.

Article 30

1. Military activities shall not take place in the lands or territories of indigenous peoples, unless justified by a relevant public interest or otherwise freely agreed with or requested by the indigenous peoples concerned.

2. States shall undertake effective consultations with the indigenous peoples concerned, through appropriate procedures and in particular through their representative institutions, prior to using their lands or territories for military activities.

Article 31

1. Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the

right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions.

2. In conjunction with indigenous peoples, States shall take effective measures to recognize and protect the exercise of these rights.

Article 32

1. Indigenous peoples have the right to determine and develop priorities and strategies for the development or use of their lands or territories and other resources.

2. States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources.

3. States shall provide effective mechanisms for just and fair redress for any such activities, and

appropriate measures shall be taken to mitigate adverse environmental, economic, social, cultural or spiritual impact.

Article 33

1. Indigenous peoples have the right to determine their own identity or membership in accordance with their customs and traditions. This does not impair the right of indigenous individuals to obtain citizenship of the States in which they live.

2. Indigenous peoples have the right to determine the structures and to select the membership of their institutions in accordance with their own procedures.

Article 34

Indigenous peoples have the right to promote, develop and maintain their institutional structures and their distinctive customs, spirituality, traditions, procedures, practices and, in the cases where they exist, juridical systems or customs, in accordance with international human rights standards.

Article 35

Indigenous peoples have the right to determine the responsibilities of individuals to their communities.

Article 36

1. Indigenous peoples, in particular those divided by international borders, have the right to maintain and develop contacts, relations and cooperation, including activities for spiritual, cultural, political, economic and social purposes, with their own members as well as other peoples across borders.

2. States, in consultation and cooperation with indigenous peoples, shall take effective measures to facilitate the exercise and ensure the implementation of this right.

Article 37

1. Indigenous peoples have the right to the recognition, observance and enforcement of treaties, agreements and other constructive arrangements concluded with States or their successors and to have States honour and re-

spect such treaties, agreements and other constructive arrangements.

2. Nothing in this Declaration may be interpreted as diminishing or eliminating the rights of indigenous peoples contained in treaties, agreements and other constructive arrangements.

Article 38

States in consultation and cooperation with indigenous peoples, shall take the appropriate measures, including legislative measures, to achieve the ends of this Declaration.

Article 39

Indigenous peoples have the right to have access to financial and technical assistance from States and through international cooperation, for the enjoyment of the rights contained in this Declaration.

Article 40

Indigenous peoples have the right to access to and prompt decision through just and fair procedures for the resolution of conflicts and disputes with States or other parties, as well as to effective

remedies for all infringements of their individual and collective rights. Such a decision shall give due consideration to the customs, traditions, rules and legal systems of the indigenous peoples concerned and international human rights.

Article 41

The organs and specialized agencies of the United Nations system and other intergovernmental organizations shall contribute to the full realization of the provisions of this Declaration through the mobilization, inter alia, of financial cooperation and technical assistance. Ways and means of ensuring participation of indigenous peoples on issues affecting them shall be established.

Article 42

The United Nations, its bodies, including the Permanent Forum on Indigenous Issues, and specialized agencies, including at the country level, and States shall promote respect for and full application of the provisions of this Declaration and follow up the effectiveness of this Declaration.

Article 43

The rights recognized herein constitute the minimum standards for the survival, dignity and well-being of the indigenous peoples of the world.

Article 44

All the rights and freedoms recognized herein are equally guaranteed to male and female indigenous individuals.

Article 45

Nothing in this Declaration may be construed as diminishing or extinguishing the rights indigenous peoples have now or may acquire in the future.

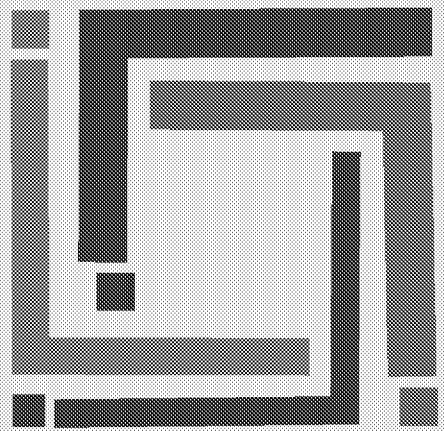
Article 46

1. Nothing in this Declaration may be interpreted as implying for any State, people, group or person any right to engage in any activity or to perform any act contrary to the Charter of the United Nations or construed as authorizing or encouraging any action which would dismem-

ber or impair, totally or in part, the territorial integrity or political unity of sovereign and independent States.

2. In the exercise of the rights enunciated in the present Declaration, human rights and fundamental freedoms of all shall be respected. The exercise of the rights set forth in this Declaration shall be subject only to such limitations as are determined by law and in accordance with international human rights obligations. Any such limitations shall be non-discriminatory and strictly necessary solely for the purpose of securing due recognition and respect for the rights and freedoms of others and for meeting the just and most compelling requirements of a democratic society.

3. The provisions set forth in this Declaration shall be interpreted in accordance with the principles of justice, democracy, respect for human rights, equality, non-discrimination, good governance and good faith.



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Statewide Threat Assessment: Identification of Threats from Erosion, Flooding, and Thawing Permafrost in Remote Alaska Communities

Report Prepared for the Denali Commission

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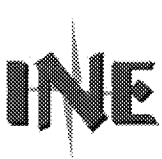

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Executive Overview

The goals of this study were to 1) assess individual threats to public infrastructure associated with erosion, flooding, and thawing permafrost in Alaska communities; 2) evaluate the combined threat imposed by interactions between erosion, flooding, and thawing permafrost in Alaska communities; and 3) provide guidance to decision makers regarding the technical information required to develop mitigation or adaptation strategies related to those threats.

The study was carried out by three entities working closely with the Denali Commission. The US Army Corps of Engineers Alaska District (USACE) was responsible for evaluating threats from flooding and erosion. The new work carried out by USACE focused primarily upon flooding, because erosion was considered extensively in the Baseline Erosion Assessment (USACE 2009) for 134 communities that were also evaluated for this study. The University of Alaska Fairbanks (UAF) Institute of Northern Engineering and the USACE Engineer Research and Development Center Cold Regions Research and Engineering Laboratory (CRREL) were responsible for evaluating the risk from thawing permafrost, as well as integrating the combined threats from erosion, flooding, and thawing permafrost into an overall score.

Data collection focused entirely on publicly available data and data volunteered by agencies or the private sector. No communities were visited, nor was any effort made to validate the data beyond a review by the study team for consistency and reasonableness. It is recognized that the amount and reliability of the data varies among the communities.

Chapters 1, 2, and 3 of this report provide information related to the scope, previous efforts, and general characteristics of the individual and combined threats, respectively. Chapter 4 describes the methodology developed and employed by the study team to attribute numerical scores to erosion, flooding, and permafrost threats across 187 rural Alaska communities. Tabulated results are provided in Appendix A.

Chapter 5 provides the summarized results of the study. The numerical results of the individual threat evaluations are grouped according to relative threat (1 = high, 2=medium, 3= low) and presented in distribution plots and maps. The groupings were developed based upon the distribution of normalized data. As described in the results, 29 communities were placed in Group 1 for erosion, 38 communities were placed in the Group 1 for flooding, and 35 communities were placed in the Group 1 for thawing permafrost. The estimated level of uncertainty for the individual threats are also presented in the results section, emphasizing that the rankings should be interpreted as a guideline rather than an inflexible list of relative threat levels. In addition, Chapter 5 presents the combined threat ranking in a distribution plot and map. As the interrelated processes between flooding, erosion, and thawing permafrost are not only themselves uncertain, but also site-specific, the study team opted against placing communities into groups of relative threat based on the combined ranking. The rankings for individual threats in each community studied are presented in Appendix A.

Chapter 6 presents the study conclusions and recommendations. In most instances, development of specific mitigation and adaptation strategies for public infrastructure in individual communities requires the collection of additional data. In Chapter 6, a generalized list of data recommendations and requirements is presented according to threat in order to guide site-specific studies.

The rankings and groupings developed under this study are intended to be used to identify those communities requiring additional investigation. However, the threat levels alone are insufficient to determine an appropriate course of action in any given community. It is intended that decision makers will utilize the estimated threat levels presented in Chapter 5, the data requirements in Chapter 6, and a substantial amount of professional judgment to allocate resources necessary to conduct more in-depth investigations and/or mitigation projects in individual communities.

Data used to develop this report as well as analytical spreadsheets have been provided to the Denali Commission. A web page has been established on the Institute of Northern Engineering website providing the public with maps and other pertinent information related to this study (http://ine.uaf.edu/projects/statewide-threat-assessment/). The website is designed such that users can access, download, and view summarized project results using widely available free software.

A more detailed database of geospatial information collected during this study will be made available for download from the UAF Scenarios Network for Alaska + Arctic Planning (SNAP) database Arctic Data Collaborative. The database was created to catalog information used to assess erosion, flood, and permafrost hazards and to present the results of the process. Final rankings for each community for the three individual hazards, a time factor, and a combined score are included. This database summarizes the information used to derive scores for each hazard, as well as provides an appropriate spatial framework for more detailed analysis by others in the future.

The information provided in this report represents a snapshot in time. The report represents an effort to provide guidance to planners and decision makers regarding the relative threat to Alaska rural infrastructure based upon readily available information collected primarily during or before February 2018. However, the evaluation techniques, as well as the data collected, are intended to be incorporated into ongoing and future efforts to understand and mitigate threats to Alaska's rural infrastructure and communities. It is recommended that stakeholder agencies build upon the information presented in this report, and collaborate to develop advanced data hosting, design, and decision support tools intended to foster a unified approach to mitigating Alaska's infrastructure challenges.

Chapter 1.0 Introduction and Scope

Communities throughout Alaska are facing threats to infrastructure imposed by erosion, flooding, and thawing permafrost. In many instances, the impacts of erosion, flooding, and thawing permafrost amplify one another to form a combined threat known as usteq. The Alaska Statewide Hazard Mitigation Plan utilized the Yupik word "usteq" to describe the compounding effects of such threats (ADHS&EM, 2018). Usteq roughly translates as "surface caves in," and is defined in the Statewide Hazard Mitigation Plan as "a catastrophic form of permafrost thaw collapse that occurs when frozen ground disintegrates under the compounding influences of thawing permafrost, flooding, and erosion." Thus, the term usteq is intended to characterize complex interactions that occur when erosion and flooding are combined with thawing permafrost.

A lack of long-term spatially or temporally discrete monitoring throughout Alaska challenges the ability of engineers, scientists, and planners to study and address the level of threat from erosion, flooding, thawing permafrost, and usteq. For many Alaska communities, the only information available to determine potential damage from these threats is found in historic records and disaster declarations or determined from anecdotal information or physical evidence. The purpose of this study is to help identify communities that may be facing such threats based upon existing data, and to recommend further data collection efforts intended to provide information necessary for assessing threats and responding to them.

The State of Alaska Immediate Action Workgroup, in 2009, recommended that a methodology be developed for prioritizing need based on risk to infrastructure from environmental threats including erosion, flooding and thawing permafrost (Immediate Action Work Group, 2009). In response to this recommendation as well as ongoing concerns statewide, the Denali Commission organized a 2016 charrette drawing in experts from government, academia and the private sector. The charrette participants confirmed that data gaps did exist, and that a methodology for prioritizing and evaluating data needs was indeed required.

Following the charrette, the Denali Commission contracted with the US Army Corps of Engineers Alaska District (USACE), the University of Alaska Fairbanks (UAF) Institute of Northern Engineering, and the USACE Research Engineering and Development Center Cold Regions Research and Engineering Laboratory (CRREL) to collaborate in a study designed to provide guidance to Alaska decision makers regarding threats to public infrastructure. USACE was selected due to their historic and ongoing work addressing erosion and flooding hazards throughout the state, including the development of a 2009 Alaska Baseline Erosion Assessment (U.S. Army Corps of Engineers, 2009). UAF and CRREL were selected based upon their expertise in permafrost impacts to infrastructure. Critical public infrastructure was taken to include, but not limited to, schools, clinics, government buildings, sanitary sewer systems (e.g., sewage lagoons), freshwater sources, airstrips, fuel tanks, and primary roads. While the study was focused on public infrastructure, it was also recognized that the impacts of these threats on housing, the environment, and culturally significant locations are also of concern to communities.

The original list of communities under study included 211 rural Alaska communities provided to the study team by the Denali Commission. The Denali Commission list did not include Alaska's larger, more urban communities because the study was designed to address data gaps in remote locations with fewer data available and limited resources for data collection. Based on preliminary evaluations of the

communities, the study team determined that 24 of the communities in the original list were either uninhabited or were subsistence camps that did not have a permanent population and no public infrastructure. Thus, the study evaluated 187 of Alaska's communities. In some cases, a single place included in this study represents multiple tribal entities residing in a common townsite. For example, the community of Kotlik consists of 3 village councils: Kotlik Tribal Council, Bill Moore's Slough, and Hamilton Tribal Council.

The study team began its work by evaluating previous efforts to determine the level of risk to communities due to erosion and flooding. In 2003, the U.S. Government Accountability Office (GAO) reported that 86% of Alaska Native communities are in some way threatened by erosion and flooding (U.S. Government Accountability Office, 2003). Nine communities were evaluated in the 2003 study and four—Kivalina, Koyukuk, Newtok, and Shishmaref— were deemed in imminent danger. In 2009, an updated GAO report evaluated 31 communities facing imminent threat from erosion and flooding, of which 12 are exploring relocation options (U.S. Government Accountability Office, 2009). In the 2009 Alaska Baseline Erosion Assessment (BEA), the U.S. Army Corps of Engineers identified 178 communities that have reported erosion problems (U.S. Army Corps of Engineers, 2009). Of these 178 communities, 26 were declared "Priority Action Communities," indicating that they should be considered for immediate action by either initiating an evaluation of potential solutions or continuing with ongoing efforts to manage erosion.

In addition to their review of previous flood and erosion publications, the study team also evaluated existing reports regarding the relative threats to Alaska infrastructure imposed by thawing permafrost. Two particularly relevant studies included *Thaw Settlement Hazard of Permafrost Related to Climate in Alaska* (Hong, Perkins, & Trainor, 2014) and *Climate Change Damages to Alaska Public infrastructure and the Economics of Proactive Adaptation* (Melvin, et al., 2016), both of which sought to describe the impacts to infrastructure imposed by thawing permafrost using a thawing settlement index which is a function of climate and ice content of the permafrost statewide. However, since the threat of thawing permafrost is highly dependent upon the characteristics and spatial distribution of permafrost immediately adjacent to the infrastructure in question, the prior statewide analyses did not have sufficient spatial resolution to provide direct measures of permafrost threat on a community-by-community basis. We know of no other previous efforts in Alaska to qualitatively or quantitatively determine the threat to individual community infrastructure statewide posed by thawing permafrost.

Following evaluation of existing data (further described in Chapter 2), the study team collaborated with Denali Commission to develop evaluation methodologies, collect existing data, evaluate the individual and combined threats, and assemble this resulting report. The threats of erosion, flooding, and thawing permafrost were assessed in the 187 communities using only readily available data. Community site inspections were not included in the study's scope of work, and no data sets were sought except those in the public domain or those that were volunteered. The data considered in this report focused upon events or information available as of February 2018. Uncertainty of community ratings vary based on available data.

This study does not provide specific recommendations for risk reduction strategies or identify funding for communities facing erosion, flooding, or thawing permafrost threats. Rather, the focus was to identify the most vulnerable communities so community members, policy makers, and government

agencies can make better-informed decisions. Anticipated actions based upon this report include collection of site-specific data pertinent to the threat(s), as recommended in Chapter 6.

To facilitate future work, all data collected in this study have been provided to the Denali Commission. A project overview including summarized results and downloadable KMZmap files is available on the UAF Institute of Northern Engineering website (http://ine.uaf.edu/projects/statewide-threat-assessment/). In addition, a database of project geospatial information will be available at the Arctic Data Collaborative, hosted by the UAF Scenarios Network for Alaska + Arctic Planning. The database was originally developed as the Alaska Hydrologic Hazard Database and included georeferenced data on riverine (rainfall, break-up/ice-jam, glacial outburst) and coastal flooding (storm surge and wave) events for communities in the State of Alaska. A relational database structure linking data sources to communities was used to facilitate intuitive data discovery, allowing users to query data using community locations as the main parameter. The structure also tied event-based flood data developed by the National Weather Service to specific communities. The project added additional data on permafrost including community-specific information on massive ice, thaw susceptibility and permafrost occurrence and temperature. Intermediate results for each hazard were added for flooding, erosion, and permafrost that relate categories including commercial infrastructure and housing distribution. Final rankings for each community for the three individual hazards, a time factor, and a combined score are included. This database summarizes the information used to derive scores for each hazard, as well as provides an appropriate spatial framework for more detailed analysis by others in the future.

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Chapter 2.0 Background

Eight sources provided a wealth of information concerning prior efforts to identify Alaska communities threatened by erosion, flooding, and thawing permafrost.

2.1 Alaska Native Villages Report – 2003

In its 2003 report, "Alaska Native Villages: Most Are Affected by Flooding and Erosion, But Few Qualify for Federal Assistance," the GAO noted that erosion and flooding, in some way, affect 86% of 213 Alaska Native communities, as evidenced by the 190 disaster emergencies recorded between 1977 and 2003. The GAO added that, while the problems are long-standing, they have not been addressed because these communities do not qualify for assistance under programs administered by USACE and the Natural Resources Conservation Service. Largely, the communities do not qualify because the projects cannot be justified based on an economic cost benefit analysis. Even if communities do meet this economic cost benefit requirement, they can find it challenging to meet the cost-share requirements.

The GAO was directed to review nine communities, of which four—Kivalina, Koyukuk, Newtok, and Shishmaref—were in imminent danger from erosion and flooding. At that time, these four communities were planning to relocate even as agencies were investing in infrastructure at their present locations.

The GAO recommended three alternatives that, separately or in combination, would have a significant impact on communities threatened by erosion or flooding:

- Expand the role of the Denali Commission to include responsibility for managing an erosion and flooding assistance program, which the commission currently does not have.
- Direct USACE and the Natural Resources Conservation Service to consider social and environmental factors in their cost benefit analyses for projects requested by Alaska Native villages.
- Waive the federal cost-sharing requirement for erosion and flooding programs for Alaska Native villages.

In addition, the GAO suggested bundling funds from agencies to address erosion and flooding in Alaska Native villages.

Update: Since the 2003 GAO publication, the USACE has been directed by Congress to begin considering non-monetary benefits (Section 116 of the Energy and Water Development and Related Agencies Appropriations Act of 2010, Public Law 111-85) for Alaska communities when determining federal interest in a potential project.

2.2 Alaska Climate Impact Assessment Commission

The focus of the Alaska Climate Impact Assessment Commission was to gain an understanding of climate change in Alaska.

The Alaska Climate Impact Assessment Commission was established in 2006 by Legislative Resolve 49 (Alaska Climate Impact Assessment Commission, 2008). While the focus of the Commission was climate change, the Commission made several recommendations that are applicable to this study:

- Update technical maps to address soils, erosion, floodplain features, surface water, stream and river course changes, and permafrost conditions.
- Develop appropriate Memorandums of Agreement between the State of Alaska and the Denali Commission, USACE, and the U.S. Departments of Interior and Transportation to establish a point of leadership on behalf of village relocation projects in the state.
- Develop best practices for engineering projects submitted to the state that address cold region conditions.
- Identify at-risk communities in need of relocation due to erosion or other potential damage and identify communities that require mitigation/protection.
- Update precipitation frequency estimates. (Note that this was completed in 2012 by the UAF Water and Environmental Research Center with funding from the Alaska University Transportation Center, Alaska Department of Transportation and Public Facilities, U.S. Department of Transportation, and National Weather Service. (Kane & Stuefer, 2013).)
- Identify funds to assess public infrastructure needs to protect against loss due to erosion and loss due to thawing permafrost.

2.3 Alaska Climate Change Subcabinet

In 2007, Alaska's Governor established the Alaska Climate Change Subcabinet under Administrative Order 238. Four groups were established under the administrative order:

- Adaptation Advisory Group
- Mitigation Advisory Group
- Immediate Action Work Group
- Research Needs Work Group

The Immediate Action Work Group (IAWG), which addressed known community threats related to coastal erosion, thawing permafrost, flooding, and fires (Immediate Action Work Group, 2009), suggested three actions:

- Identify the communities at risk, the timeframe, and actual needs to address climate change impacts.
- Develop a methodology for prioritization of needs based on the risks to health, infrastructure, homes, businesses, subsistence harvests, significant cultural attributes, and quality of life.
- Determine the needs of coastal communities subjected to climate change impacts.

While the IAWG worked within the climate change agenda established by the executive order, its focus was on near-term needs, resulting in the identification of six communities that required action within 18–24 months.

2.4 Alaska Baseline Erosion Assessment

In 2009, USACE published the Alaska Baseline Erosion Assessment (U.S. Army Corps of Engineers, 2009), which identified 178 communities in Alaska as having erosion problems ranging from minor to severe. The BEA categorized the study communities into three groups: "Priority Action Communities" (26), "Monitor Conditions Communities" (69), and "Minimal Erosion Communities" (83). The BEA summarized the community survey as follows:

- Sixty-eight of the 127 respondents indicated riparian or coastal erosion or both in their communities.
- Twenty-five percent of respondents indicated that erosion is ongoing gradual threat.
- Nineteen percent of respondents indicated erosion was due to discrete events.
- Seventeen percent of respondents indicated they were experiencing both types of erosion.
- Thirty-nine percent of respondents were unable to answer the question.

The survey indicated that the success of corrective measures was variable. While 44 communities reported that protective measures had been effective, 14 of these communities noted that there had been some partial failure over time. Another 23 communities reported that measures undertaken had failed.

Corrective measures typically include some type of fill material—concrete blocks, gabion baskets, 55-gallon drums, dikes, and tree branches—which is not surprising since many communities lack rock that can be used for riprap and lack the funding needed for more permanent measures (U.S. Government Accountability Office, 2009).

The 2009 BEA developed a list of 26 communities considered Priority Action Communities that warrant "immediate and substantial" intervention. The process used to select these communities will be discussed in detail later in this report.

2.5 Alaska Native Villages Report – 2009

In its 2009 report, "Alaska Native Villages: Limited Progress Has Been Made on Relocating Villages Threatened by Flooding and Erosion," the GAO noted the lack of progress on relocating Alaska Native villages threatened by erosion and flooding and pointed out that the 2009 BEA only included communities threatened by erosion (U.S. Government Accountability Office, 2009). The GAO chose to address 31 communities identified by federal, state, and village officials, which included 5 communities threatened by flooding, along with the 26 Priority Action Communities identified in the BEA. The GAO recommended that Congress consider these actions:

- Directing USACE to conduct a flooding assessment to augment its recently completed erosion assessment.
- Amending the Housing and Community Development Act of 1974 to allow 64 additional villages to be eligible grant recipients.
- Designating, or creating, a lead federal entity that could work in conjunction with the lead state agency to coordinate and oversee village relocation efforts.

2.6 Other Related Literature

2.6.1 Imperiled Community Water Resources Analysis

At the request of the Immediate Action Work Group (IAWG), Tetra Tech prepared an evaluation report of risk to water infrastructure due to climate change in 214 communities (Tetra Tech, 2010). The Imperiled Community Water Resource Analysis (ICWRA) provides insight into potential threats to public water/wastewater systems. Communities were prioritized using a process similar to that used by the BEA in 2009. Tetra Tech used four criteria developed by the IAWG for selecting and ranking communities regarding their water infrastructure:

- Life/safety risk during storm/flood events.
- Loss of critical infrastructure.
- Public health threats (as defined by the Centers for Disease Control and Prevention) or by Alaska's Regional Health Corporations.
- Loss of 10% or more residential dwellings.

Using available data, including that from the BEA, the ICWRA found that 23 communities currently face some threat to water infrastructure, and 44 communities may face threat to water infrastructure at some point. The latter group either faced lesser threats or did not supply enough information to confidently assess those threats. The report contained six recommendations:

- Supplement this analysis with a more detailed analysis.
- Collect additional hydrologic data.
- Increase permafrost monitoring.
- Adopt prevention and adaptation strategies for managing water and wastewater assets.
- Mitigate landfill and tank farm risk.
- Implement relevant recommendations from the Governor's Climate Change Subcabinet Adaptation Advisory Group.

The ICWRA report contains community profiles of priority communities and includes potential impacts from erosion, flooding, and thawing permafrost, information that is useful to this study's threat analysis.

2.6.2 Thaw Settlement Hazard Index

Hong et al. (2014) developed a Permafrost Settlement Hazard Index (PSHI) that uses six ecosystem characteristics—topography, surface water, groundwater, soil properties, vegetative cover, and snow cover—to estimate thaw settlement in permafrost. Using the analytic hierarchy process developed by Saaty (Saaty, 2008), the authors developed a PSHI, combining the relative importance of ground temperature, ground ice, soil texture, snow depth, and organic soil content. Referring to permafrost maps developed by Jorgenson et al. (Jorgenson et al., 2010), to vegetation maps developed by Fleming (Fleming, 1997), and to temperature maps developed by SNAP (Scenarios Network for Alaska & Arctic Planning, 2010), Hong et al. used the GIS (Geographic Information System) to develop PSHI maps for Alaska. The research group then added communities for which the risk of thaw subsidence could be estimated. The maps used to develop the PSHI resulted in a generalized map of permafrost settlement threat at the regional level. That said, in-depth analysis of community infrastructure requires consideration of not only the ground conditions, but also consideration of the type, design, and distribution of infrastructure within each community. Thus, the PSHI maps developed by Hong et al. provide a starting point, but not an endpoint, for an in-depth analysis of each community.

2.6.3 Cost of Infrastructure under Greenhouse Gas Scenarios

Another pertinent study is by Melvin et al. (2016), in the *Proceedings of the National Academy of Sciences of the United States of America.* This study evaluated projected costs of infrastructure damage under various greenhouse gas scenarios. The study predicted that the largest drivers would be flood damage to transportation infrastructure in Interior and Southcentral Alaska due to changes in hydrology, as well as damage to buildings based on thaw of near-surface permafrost. This analysis was primarily a cost analysis, ultimately expressing damages in units of repair dollars. A drawback of this assessment is that the infrastructure components were assigned to relatively large grid cells, which were then

assessed according to predicted climatic impacts. However, erosion, flood, and especially permafrost impacts tend to be highly dependent upon the specific location of the infrastructure within the grid cells. Permafrost damage, for instance, is highly dependent upon the specific soil and ground ice conditions underlying the infrastructure and the engineering controls put into place during or after construction. Thus, from an engineering perspective, a large-scale evaluation such as this one would not be enough to provide predictive capability for specific units of infrastructure. However, the study was useful in describing the parameters of the thawing permafrost challenge.

2.7 Summary

Several of the reports described above identified specific communities that were most threatened by some combination of threats pertinent to this study. Thus, it is informative to consider which communities were among those considered most threatened by multiple reports. Table 2-1 is a summary of the communities that the highlighted reports designate as "threatened." While there is overlap among these reports, consensus should not be expected since the focus of each report is on different threats and different infrastructure, and the reports were prepared by different teams over a period of years (2003-2016). The reports noted in Table 2-1 laid the foundation for this study, providing invaluable background information and data, as well as insight into the driving forces behind the project.

Table 2-1. Summary of at-risk communities identified by highlighted reports.

Community	GAO, 2003	BEA, 2009	IAWG, 2009	GAO, 2009	ICWRA, 2010
Akiak		*		*	
Alakanuk		*		*	
Aniak					*
Atmautlauk					*
Allakaket				*	
Utqiaġvik (Barrow)		*		*	
Brevig Mission					*
Chalkyitsik					*
Chefornak		*		*	
Chevak		*		*	*
Chignik Lagoon					*
Clark's Point		*		*	
Cordova/Eyak		*		*	
Deering		*		*	*
Dillingham		*		*	
Diomede					*
Emmonak		*		*	*
Golovin		*		*	
Hughes				*	*
Huslia		*		*	*
Kivalina	*	*	*	*	
Kotlik		*		*	
Koyukuk	*		*	*	
Kwigillingok		*		*	
Lime Village		*		*	
McGrath		*		*	*
Napakiak		*		*	
Nelson Lagoon					*
New Stuyahok					*
Newtok	*	*	*	*	
Noatak					*
Nulato				*	
Nunapitchuk		*		*	
Port Heiden		*		*	
Quinhagak					*
Saint Michael		*		*	*
Selawik		*		*	*
Shaktoolik		*	*	*	
Shishmaref	*	*	*	*	
Stebbin					*
Talkeetna					*
Teller				*	*
Unalakleet		*	*	*	
Venetia					*
Wales					*

Chapter 3.0 Erosion, Flooding, Thawing Permafrost, and Combined Threat

The vulnerability of 187 communities to three infrastructure threats—erosion, flooding, and thawing permafrost—were evaluated individually in this report. These threats generally operate at different timescales and impact infrastructure through different processes. Any of these threats can be catastrophic to a community. When combined, the impacts can be exacerbated, resulting in usteq.

Of the threats described above, erosion is the most readily observed and identified. The erosion process is continuously observable at the point of impact, although the rates may vary according to conditions. Prediction of erosion usually involves observations of current rates and consideration of potential changes to those rates. Flooding, on the other hand, is readily observed during a flood event, but is a discontinuous process. Prediction of future floods is based upon the frequency of past floods, sometimes in conjunction with predictions of potential changes in climatic conditions. The threat of damage via thawing permafrost is highly dependent upon subsurface conditions, which are themselves often poorly characterized. Moreover, thawing permafrost damage is also dependent upon a host of other factors including engineering design and climatic conditions. Thus, thawing permafrost is not only difficult to observe until after the infrastructure has been damaged, but is also relatively difficult to predict in areas where damage has not yet occurred. Usteq is the most difficult to predict because it incorporates the uncertainties associated with each individual threat. Usteq is a subset of the combined threats but was not separated for the purpose of this study. The occurrence of usteq does not conflict with the combined scores. When the threat of permafrost thaw is high in a location also subject to erosion and flooding, the occurrence of usteq may be high.

The purpose of this chapter is to provide additional background information regarding the individual and combined threats, in order to provide context for the interpretation of study results.

3.1 Erosion Threat

For the purposes of this study, erosion is defined as the removal of soil, either thawed or frozen, due to the movement of water. Erosion places communities at risk when the erosion process causes a net migration of the top of the shoreline or riverbank toward fixed infrastructure. When the shoreline or bank line reaches community infrastructure it undermines foundation material, causing structural failure of buildings, utilities, and transportation facilities. The processes for erosion can be subdivided into two broad categories: coastal erosion and riparian erosion.

Coastal erosion is primarily due to ocean current, wave action, and/or storm surge. Wave action is the most common cause. Coastal erosion is usually described in terms of sediment transport, which is identified by the volume and direction of material moved along a coastline, longshore or cross-shore. The rate of sediment transport is dependent upon wave energy and direction along a section of coastline, as well as the material composition of a shoreline. Most dynamic shorelines are composed of coarse to fine sand, which is more easily transported by wave action. In some high energy environments, beaches are formed of gravel, cobbles, and boulders, which are only transported by larger wave action.

Longshore sediment transport occurs when waves approaching the coastline at an angle move beach material down the shoreline in the same direction as the waves, an action also known as the direction of sediment drift. This process is dependent on the availability of sediment from updrift locations and on the

wave-energy affecting a site. When considering a section of coastline, if the volume of material being transported into an area is the same as the volume transported out, the beach is in equilibrium, and no erosion or accretion occurs. If more material enters the section of coastline than leaves it, accretion occurs, with the beach width and elevation increasing and dune formations, if present, increasing in size. If more sediment leaves the area than enters it, a sediment deficit occurs, and the shoreline retreats inland.

Cross-shore sediment transport occurs when material along the beach profile is moved either onshore to higher elevations, or offshore to lower elevations, depending on the wave conditions. During mild wave conditions, typically during summer months in Alaska, material is deposited on the upper slopes of the beach, which builds up the shoreline. During fall and early winter, storm events produce more energetic wave conditions, which tend to erode material from the shore and deposit it in an offshore bar. When net transport over time is offshore, the shoreline retreats inland (Figure 3-1).

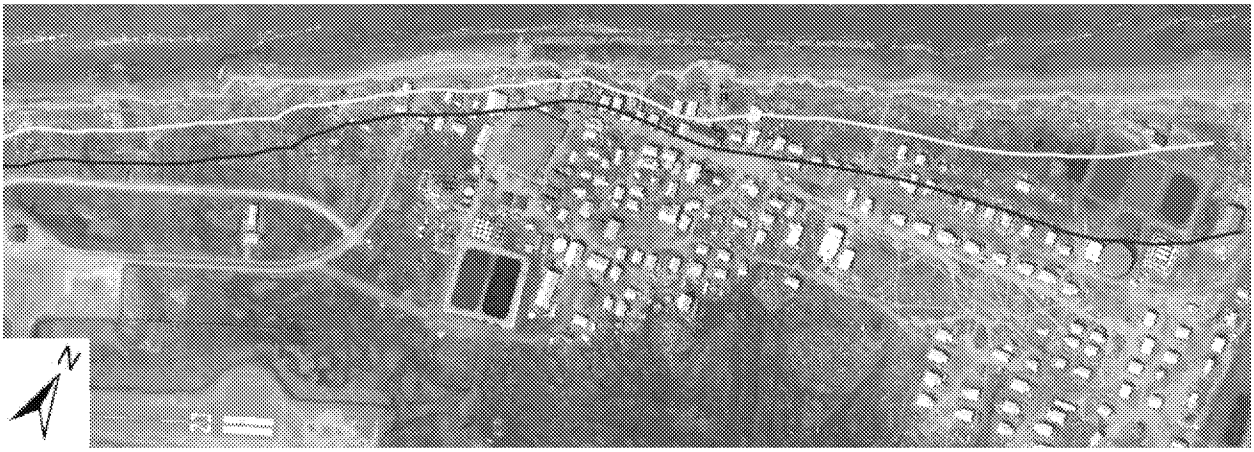

Figure 3-1. Shishmaref, Alaska, erosion prediction assuming no coastal protection.

In Figure 3-1 above, this site is subject to coastal sediment transport processes. The colored lines represent shorelines, as reported in the 2009 BEA: green is the 2004 shoreline, pink is the 2013 predicted shoreline, yellow is the 2028 predicted shoreline, red is the 2053 predicted shoreline.

Shorefast ice that forms in the fall protects the shoreline from damaging energetic fall storms. Between 1976 and 2007, the extent of shorefast ice in the Arctic has decreased by approximately 0.7% per year (Yu Y. , Stern, Fowler, Fetterer, & Maslanik, 2013). In 2006, NOAA began publishing an annual peer-reviewed Arctic Report Card. In the 2018 Report Card, researchers reported that "pan-Arctic observations suggest a long-term decline in coastal landfast (herein referred to as *shorefast*) sea ice since measurements began in the 1970s, affecting this important platform for hunting, traveling, and coastal protection for local communities (Osborne, Richter-Menge, & Jeffries, 2018)." With decreasing shorefast ice extent, coastal communities could be exposed to ocean currents, wave action, and storm surge for a longer period, putting infrastructure at greater risk of being undermined by erosion.

Riparian erosion is primarily due to river currents. Rivers and streams are dynamic systems that respond to changes in flow and sediment. Usually, these changes alter the course of a stream or the shape of its banks. The current of a river typically flows fastest over the deepest portion of the channel, called the thalweg. Most streams in Alaska are meandering streams that follow sinuous paths. At river bends, the thalweg is located along the outside bend, often called the cut bank. At the cut bank, higher velocity currents flow adjacent to the bank and result in erosion. Along the inside bank, or point bar, the current

is slowest (Figure 3-2). These slower currents tend to cause deposition. By these two processes, rivers tend to meander toward the outside banks of their bends. Over time, the channel of the river will shift laterally. Many communities in Alaska build infrastructure on the cut bank of a channel to take advantage of the greater water depth along the thalweg. Deeper water enables the use of barges to deliver goods and materials to a community; however, it also makes ground near the barge landing susceptible to erosion that can undermine infrastructure. Boat wakes also contribute to this process, though wakes can cause erosion on both banks of a channel. In areas of high boat traffic, channels generally become wider over time as waterline erosion causes steepening and calving of the riverbanks.

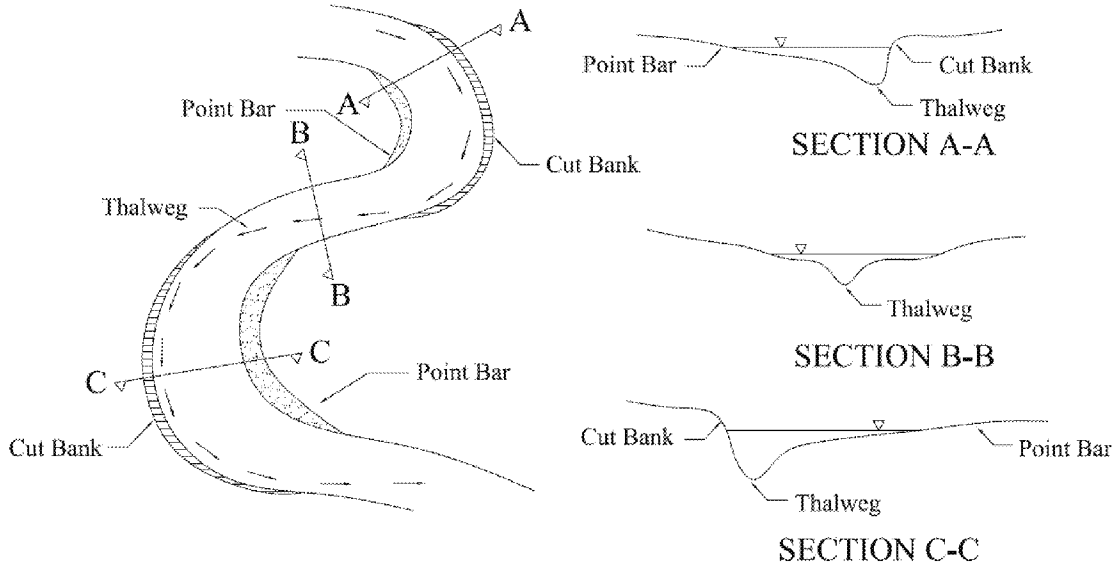

Figure 3-2. Morphology of a meandering stream (from 2009 BEA).

Flow conditions on rivers constantly change. Seasonal changes due to precipitation and freezing can cause dramatic changes in channel flow, moving from virtually no flow (freezing) to flood stage (large rainstorm or thawing events). While erosion can be a continuous process in streams, it is usually most significant during high-flow events. Flow velocity is greatest when a reach is at stream-forming flow, when the water level is at the top of the bank but not in the floodplain. This stage causes the greatest rates of erosion. Beyond seasonal changes, long-term climatic trends can either increase or decrease the amount of water a river carries. Rivers react to changes in flow by altering channel geometry to best accommodate the water. A channel experiencing increasing flow may become wider and straighter to allow it to carry the water to its terminus more quickly. Where flows are reduced, the channel may become braided as velocities decrease, causing suspended material to settle out more quickly.

In braided river systems, such as the Tanana and Matanuska rivers in Alaska, the amount of sediment available to the system far exceeds the water's ability to transport it downstream. The channel extents are defined by a braid plain that developed where the channel has historically run. The main flow of these rivers is unpredictable, and channel avulsion can rapidly change the river course within the braid

plains. When the channel runs against the edge of the braid plain, erosion will occur, potentially very rapidly, depending on the material at the braid plain boundary.

3.2 Flood Threat

For the purpose of this study, flooding is the inundation of infrastructure or the impassibility of airstrips and roads due to elevated water levels along a coast (Figure 3-3) or river (Figure 3-4). Flooding becomes a risk to the viability of a community when it threatens use of and access to critical infrastructure. Flooding also poses risk to life when inhabited areas become inundated with moving water, which can carry residents downstream or offshore.

Figure 3-3: Coastal flooding in Golovin, Alaska, September 2005 (photo courtesy of the National Weather Service).

Figure 3-4. Flooding in Galena, Alaska (photo courtesy of the National Weather Service).

Coastal flooding can be caused by elevated water levels due to highest astronomical tides, wave setup, or storm surge. In addition to elevated water caused by these processes, waves can wash up over a beach and into developed areas, causing inundation. These events may carry debris (logs, etc.) into communities posing a potential threat to critical infrastructure, housing, and human health.

Storm surge is the most common cause of flooding in coastal Alaska. The National Weather Service defines storm surge as the abnormal rise of water generated by a storm, over and above the normal highest astronomical tide; a surge is expressed in terms of height above predicted or expected tide levels. Storm surge severity depends on strength and duration of the driving storm event as well as coastline geometry and bathymetric profile. Topography beyond the beachline also determines how much land is susceptible to such surges. While storm surge is an issue throughout western Alaska, Norton Sound communities experience some of the most severe events.

As relative sea level change is realized, the depth of storm surge flooding may increase in areas that experience rising relative mean sea level. The changes in shore-fast ice extent also affect the period of time that the shoreline is exposed to storm surge. If local shore-fast ice decreases, the community's infrastructure, which historically has been shielded by shore-fast ice, may be at risk due to storm events.

River flooding can be caused by elevated water levels due to ice jams, large rain events, frequent, consecutive small rain events, quick melting of snowpack, or a breaking earthen or ice dam. In all these cases, the conveyance capacity of the channel is exceeded, and excess water is impounded in the overbank areas where infrastructure is located. Flood severity is typically classified by the peak elevation of water within a community. This usually corresponds to the highest flow in the river; however, ice jams add impoundment to the problem and cause elevations higher than the flow of the river alone would produce.

Flood frequency is typically measured statistically using a record of peak elevations at a fixed location and is based upon a probability that the water surface elevation will exceed a defined level in any given year. This is expressed as an annual exceedance probability. Historically, the return periods for these probabilities were expressed in years; for instance, a water elevation that has a 1% chance of occurring every year was estimated to occur on average once every 100 years; hence the term "100-year flood." This terminology leads to the misconception that once a severe flood has happened, it will be less likely for a similar event to occur for a long period of time (100 years, in popular thought). In truth, a 100-year flood has an equal probability of occurring in any given time, regardless of the amount of time elapsed since the last 100-year flood.

Climate change may be altering the historic patterns of rainfall, snowmelt, and thermal ice breakup. The 2018 Arctic Report Card addresses changes in discharge patterns across the pan-Arctic between the reference period 1980–1989, and 2018 (Holmes et al., 2018). The combined daily discharge of the Yukon River and Mackenzie River, located predominantly in the Yukon Territory, Canada, peaked four days earlier in 2018 than the average day during the reference period and had a total discharge between July 15 and September 30 that was 4% greater than the average during the reference period (Holmes et al., 2018). Bennett et al. (2015) studied the historic trends and extremes of river flow for basins ranging from the Chena and Salcha basins near Fairbanks, Alaska, to the Susitna basin in southcentral Alaska, east to the Yukon at Eagle, and west to the Nuyakuk near Dillingham. The researchers found that the period of time of change is dependent on a system's physical response to climate change. For snowmelt-dominated systems, the maximum spring streamflow is increasing. For glacial systems, streamflow is declining in spring, in summer, and annually. Across many river systems in Alaska, the winter baseflow was observed to be increasing. Thus, while the probability of future flood events (and hence the level of threat to infrastructure) are commonly predicted based upon the frequency of past flood events, dynamic climatic trends can impart uncertainty into those predictions.

3.3 Thawing Permafrost Threat

Thawing permafrost has long been recognized as a threat to infrastructure built upon it. Indeed, Major Wilds P. Richardson, an early 20th Century Alaskan highway commissioner, observed that "A serious detriment to the making of a road in Alaska is the thawing of the ground beneath the moss. It has been the universal experience that whenever the moss is cut into, thawing immediately commences..." (Naske, 1983). Thus, Major Richardson's observation brings to light an important consideration with respect to the threat of thawing permafrost. Permafrost thaws when the thermal balance of a frozen soil is altered. The thermal balance can certainly be altered by climatic effects but can also be altered by the construction of infrastructure itself, or by the heat transferred through existing infrastructure to the underlying soils.

Permafrost is defined as any soil or rock that remains at or below 0°C for two or more consecutive years and may or may not contain ground ice (van Everdingen, 1998). The potential for damage due to thawing permafrost is related to the ice content of the soil, surface cover, and the surface energy balance. The greater the ground-ice content, the greater the potential for damage due to loss of structural integrity of the soil. While in some cases surface features provide clues as to occurrence of massive ice bodies (Figure 3-5), there is no guarantee that the ground-surface features will indicate the subsurface ice content. The only means to accurately determine the amount of ground ice is to perform a thorough geotechnical investigation. Even with an investigation, it may be difficult to predict the ice

content outside the investigation area due to spatial variations in soil structure. Geotechnical investigations are usually performed for design or construction of a specific building, roadway, or other infrastructure. It is rare that investigations are sufficiently comprehensive to describe the permafrost characteristics underlying an entire community.

Damage to infrastructure due to thawing permafrost is rarely well documented. It is difficult to identify the number of structures damaged by naturally thawing permafrost, compared with structures that have failed due to poor engineering, construction, and/or maintenance (Figure 3-6). However, it is well known that the thermal imbalance caused by the infrastructure typically leads to thawing of permafrost either directly or indirectly. Heat from the building itself is widely recognized as a factor that contributes to thermal imbalance; however, snowdrifts, reflected sunlight, shading, destroyed vegetation, and changes in drainage patterns can all contribute to thermal imbalance. In addition, increases in surface temperatures and changes in precipitation due to climate change also play a role in thawing of permafrost.

Thaw-related impacts associated with engineering design or surface modification generally begin shortly after construction of infrastructure, and the damage may be dramatic. Impacts due to climate change generally occur over a longer period of time and are often masked by the impacts resulting from the construction of the infrastructure. Since warmer permafrost such as that produced by climate change is more susceptible to damage from infrastructure-related surface modifications, it is often difficult to attribute specific causation to any given event.

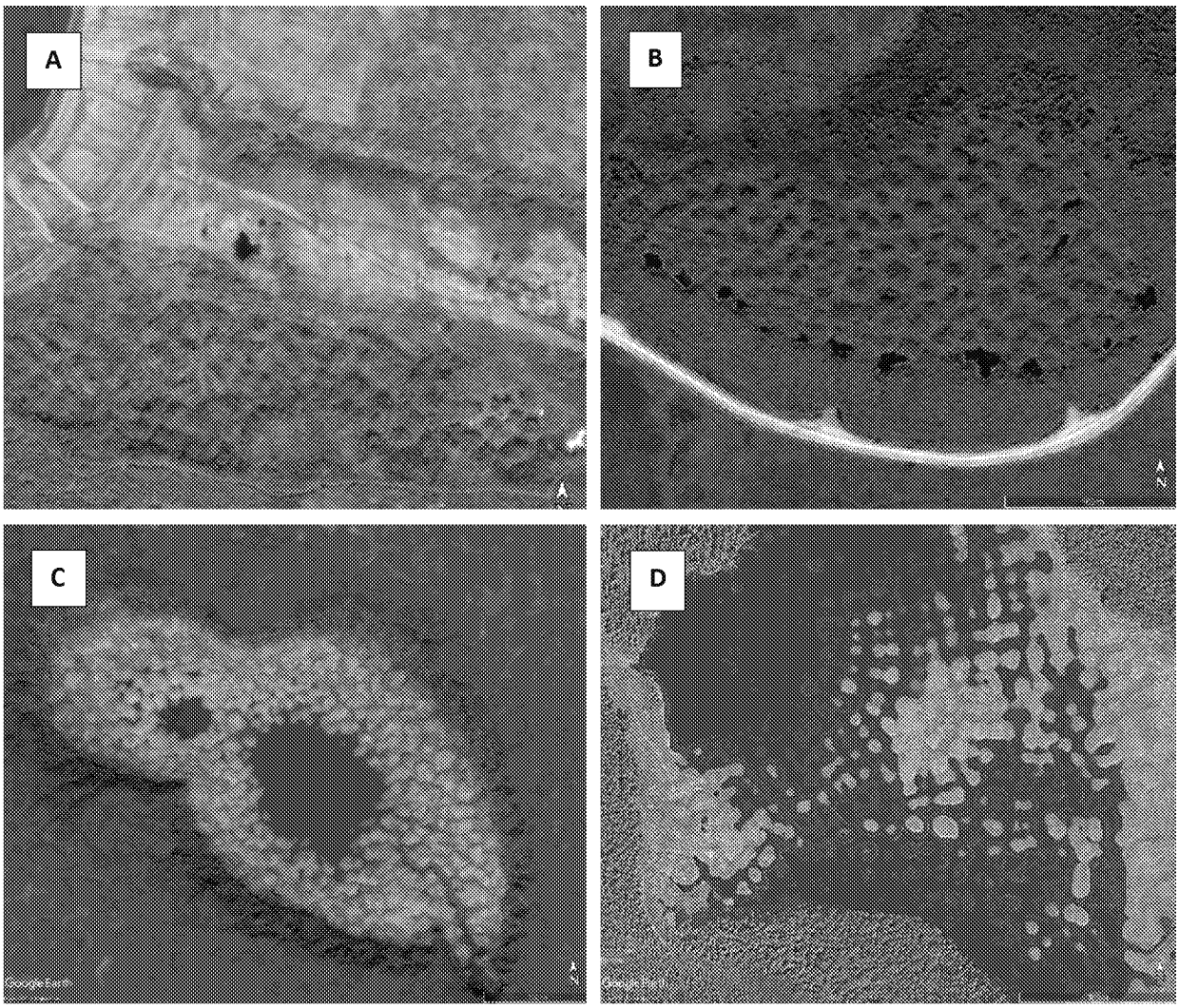

Figure 3-5. Baydzherakhs (conical thermokarst mounds that form as a result of thawing of the upper permafrost with large ice wedges): A – near Kotzebue airport; B – near Buckland; C – at the bottom of partially drained thaw-lake basin, Seward Peninsula; D – at the bottom of partially drained thaw-lake basin, Horseshoe Lake, Interior Alaska.

Figure 3-6. Crushed carrier line in Pt. Lay, Alaska, due to thawing permafrost (photo courtesy of UMIAQ Environmental, LLC).

3.4 Combined Threat

Though threats from erosion, flooding, and thawing permafrost were evaluated separately in this report, there can be a feedback loop between the threats.

The eroding riverbank at Newtok, Alaska provides an excellent example of usteq. Usteq is a subset of the combined threats, and represents the impacts flooding and erosion can have upon sites also subject to permafrost thaw. In Newtok, ice rich permafrost along the bank would likely thaw relatively slowly in the absence of other processes. However, waves and storm surges caused by autumn storms now batter the bank due to loss of sea ice. If the soils were composed of sands and gravels the erosion rate would likely be slower than observed. However, the loss of land in Newtok is very rapid, in excess of 80 feet per year (Personal conversation with Gavin Dixon, ANTHC). This is because the ice-rich frozen silts newly exposed to the elements by waves and storm surge tend to thaw quickly, thus decreasing structural stability. As a result, the historic town site of Newtok is not expected to be viable within a few years.

Figure 3-7. Crumbling blocks of permafrost along the Beaufort Sea coast (photo courtesy of the USGS).

While the processes at Newtok provide one example of usteq, usteq should not be considered a process limited to coastal or riverine sites. Water conducts heat much more readily than air, for example. Thus, any contact of water with ice rich permafrost in coastal, riverine, or terrestrial environments may cause rapid thaw and resultant infrastructure damage.

The interactions between erosion, flooding and thawing permafrost often become clear after the onset of usteq, but their combined impacts are rarely considered beforehand. This is due to a lack of knowledge regarding how best to predict the interaction between the threats. Predictions of erosion, flood, and thawing permafrost damage are themselves fraught with uncertainty and highly dependent upon the location and design of the infrastructure within each community. When attempting to predict the interactions between these threats, this uncertainty is compounded. As a result, this report does not attempt to parse the combined scores in individual communities into semi-quantitative groups such as "high" or "low" threat. Instead, the combined scores are represented as an aggregate of the individual threats.

Chapter 4.0 Risk Evaluation, Criteria, and Methods

4.1 Overview

A team of scientists and engineers from UAF, USACE, and CRREL evaluated erosion, flooding, and thawing permafrost threats for 187 communities across Alaska. The evaluation was conducted through a series of in-person team meetings during early 2018, as well as close collaboration between the team and the Denali Commission thereafter. The analytical approach was modeled after the approach employed for the BEA, using similar criteria for the ratings (U.S. Army Corps of Engineers, 2009). In the current study, USACE developed flood and erosion ratings, while UAF and CRREL developed thawing permafrost ratings. The team then collaborated on the development of an algorithm to compile the individual ratings into a combined (or aggregate) threat rating. This chapter describes the analytical process employed to develop the ratings for the individual threats of erosion, flood, and thawing permafrost, and to introduce the rationale behind the combined ratings.

4.2 General Process of Developing Ratings

Techniques for attributing ratings to individual communities were developed by an expert panel of scientists and engineers from UAF, USACE, and CRREL. The panel determined which criteria to evaluate, and how best to interpret the criteria in the context of erosion, flood, and thawing permafrost threats. In addition, the panel established the most effective methodology to scale, weigh, and assign values to the criteria. A schematic describing the overall analytical process employed in this study is presented in Figure 4-1 at the end of this chapter.

The expert panel sought to apply and score evaluation criteria consistently for each individual threat across all 187 communities. For a given community, the following steps were followed during the rating process. This process was repeated for each evaluation of erosion, flooding, and thawing permafrost:

1. Gather all available data pertaining to the threat in question for the community (see Sections 4.3, 4.4, and 4.5).
2. Determine the best fit **Impact Rating** from 0 (no impact) to 3 (high impact) for each of nine evaluation criteria using the information available (Section 4.6). Combine the individual evaluation factors into an **Aggregate Impact Rating** by applying the relative weights to each factor and then summing the factors.
3. Estimate the most likely **Time to Damage** using the information available (Section 4.7).
4. Calculate the **Risk Rating** based upon the **Aggregate Impact Rating** and **Time to Damage** (Section 4.8).
5. Rate the overall level of **Uncertainty** associated with the evaluation (see Section 5.4).

For erosion and flooding, the 187 community ratings were performed by three USACE engineers. Several ratings were performed as a group to help develop consistency. Afterwards, the remaining communities were divided, and evaluations were performed individually. When evaluations were complete, the panel reviewed the ratings together for consistency and errors and made changes as appropriate.

Whereas statewide erosion and flood data are generally available via public data sources, thawing permafrost data is scarce, and not often measured directly. Thus, the permafrost team, composed of

eight engineers and scientists from UAF and CRREL, conducted a preliminary evaluation intended to produce data suitable for implementation in Steps 1-5 as described above. In the preliminary analysis, predominant permafrost occurrence, temperature, thaw susceptibility, massive ice, and known problems were assessed and assigned a preliminary score (see Table 4-1 for preliminary criteria). These values were then summed to determine a preliminary permafrost risk level for each community based primarily upon soil characteristics. Once the preliminary permafrost risk was determined, the expert panel utilized that value plus additional community information (e.g., location and distribution of infrastructure, etc.) for application in steps 1-5 as described above.

Detailed information regarding the preliminary assessment of permafrost risk can be found in (Kanevskiy, et al., 2019). In that report, the risk levels for each of the 187 communities evaluated are provided so that each community may use the information for community planning purposes. A planning tool developed to present the permafrost data from the preliminary report is available online at the following url: https://www.snap.uaf.edu/tools/permafrost. Note: The data presented in that preliminary report are insufficient for design and construction of individual buildings or other infrastructure. Rather, the data are intended to be used as a starting point to plan geotechnical investigations.

Table 4-1. Preliminary evaluation matrix for permafrost-related threats based on soils criteria.

PF occurrence	PF temperature	Thaw susceptibility	Massive ice	Existing problems	Risk level (ranking score)
0. No permafrost	**0.** No permafrost	**0.** No permafrost	**0.** No permafrost	**0.** No permafrost	**No risk (0)**
1. Mostly unfrozen soils with isolated patches of PF	**1.** Mean annual ground temperature (MAGT) < -5°C	**1.** Almost no excess ice, thaw settlement is less than 0.1 m;	**1.** No massive ice	**1.** No PF-related problems (or minor problems)	**Low risk (5-8)**
2. Discontinuous permafrost (intermittent distribution of PF and unfrozen soils, numerous open and/or closed taliks)	**2.** MAGT = -5 – -2°C	**2.** Thaw settlement is 0.1 to 1.0 m	**2.** Sparse small to medium ice wedges (inactive or slightly active), rare occurrence of buried ice	**2.** Moderate problems	**Medium risk (9-11)**
3. Continuous permafrost (rare taliks exist only under large and deep waterbodies)	**3.** MAGT = -2 – >0°C	**3.** Thaw settlement is more than 1 m	**3.** Abundant large ice wedges close to the surface (yedoma and/or active modern wedges)	**3.** Severe problems	**High risk (12-15)**

4.3 Erosion Data Sources

Since the BEA criteria were used as a model for the criteria in this report, the BEA itself served as a primary source of erosion data (U.S. Army Corps of Engineers, 2009). Indeed, BEA data were available as source data for 132 communities evaluated in this report. The list of additional data sources for erosion is provided below. Note that for erosion as well as for the other threats, the amount of readily available information varied widely between communities:

- USACE Baseline Erosion Assessment.
- Maps detailing local topography, hydrography, and infrastructure.
- Alaska Department of Commerce, Community, and Economic Development (DCCED) online resources including the Community Index and the Community Plans Library. These include:
    - Community population
    - Number of occupied and vacant residencies
    - Hazard mitigation plans
    - Community development plans
    - FEMA National Flood Insurance Program (NFIP) information
- Additional online news sources.

4.4 Flood Data Sources

For flooding, the team predominantly relied on historic information regarding the frequency and magnitude of flooding. Most of the sources were available in the National Weather Service Flood Database and Hazard Mitigation Plans. The data sources used to determine the threat ratings for flooding are as follows:

- Maps detailing local topography, hydrography, and infrastructure.
- Alaska Department of Commerce, Community, and Economic Development (DCCED) online resources including the Community Index and the Community Plans Library.
- National Weather Service Alaska–Pacific River Forecast Center Draft Alaska Flood Database including:
    - Number of floods
    - Cause and severity of flood
    - Disaster Declarations
    - Costs of damage, specific infrastructure affected
    - Evacuations
- USACE Alaska District's Floodplain Data electronic files including:
    - Flood data sheets
    - Trip reports
    - Studies
    - Community surveys
    - Maps and photos
- Internet—an online search to find news articles reporting on flooding in the communities.

4.5 Thawing Permafrost Data Sources

As described in Section 4.2, much of the permafrost data was subjected to a preliminary analysis prior to evaluation under the BEA-derived criteria. Thus, the preliminary analysis itself served as a primary data source for further consideration (Kanevskiy, et al., 2019). Data sources for the preliminary analysis and/or the primary evaluation described in this report include:

- Alaska Department of Commerce, Community, and Economic Development (DCCED) online resources including the Community Index and the Community Plans Library.
- Alaska Department of Transportation & Public Facilities geotechnical reports.
- Engineering community geotechnical reports.
- Scientific literature describing permafrost distribution and related information.
- Satellite and air photos.
- Terrain maps.
- Surficial geology maps.

4.6 Initial Erosion, Flooding, and Thawing Permafrost Evaluation Factors Workshop

The study group (UAF, USACE, and CRREL) met on the UAF campus in February 2018 for a three-day workshop to develop the evaluation factors used for community assessment. The goal of the workshop was to identify a rating system to determine the relative impact of erosion, flooding, and thawing permafrost threats across communities. The 2009 BEA was used as a template for developing the evaluation factors.

After initial brainstorming and screening in order to include thawing permafrost threats, the group generated a list of evaluation factors with associated impact ratings. The study group added a "zero impact" rating to the rating system to capture circumstances that produced no impacts, or for communities not experiencing a threat. The evaluation factors were initially applied to each community, without consideration of the frequency of the threat impacts (short-term to long-term). The intent of the initial score was to evaluate each community equally, based solely on the type of threat and its impact. The nine evaluation factors are listed below, and their relative impact ratings (in parentheses) are described in Table 4-2.

Critical Infrastructure. Critical infrastructure included facilities in the community that, if destroyed, would affect the community's viability if not replaced quickly. Critical infrastructure include clinics, water supply, roads and airports, water/wastewater systems, water storage, schools, and the Post Office.

Human Health and Safety. Human health and safety focused on a community's ability to seek emergency services due to a threat. For example, if a road that connects a community to emergency services would be threatened, or if airport facilities would be jeopardized, the community impact was rated high. Damage to critical infrastructure affects human health and safety only when the damage directly impacts the delivery of health services. For example, damage to a clinic would impact health and safety only if the damage is severe enough to impede health services. As such, the impacts to infrastructure may affect the rating of both critical infrastructure and human health and safety.

Subsistence and Shoreline Use. Subsistence and shoreline use examined whether the community's ability to gather natural resources would be threatened. For example, if a community lost the ability to launch boats or if the only land available for processing catch was compromised, the community impact was rated high.

Land Use/Geographic Location. Land use/geographic location focused on whether a community has room to retreat from a threat, whether the land is highly susceptible to that threat, and the community's relative impact on surrounding communities. For example, a community situated on a spit of land affected by a threat with no area to retreat was rated high. If the community was situated on a bluff with adequate safe ground, the impact was rated low. An impacted community serving as a hub, providing goods and services to other communities, received a higher impact rating. Regional communities such as Galena, Nome, Bethel, Kotzebue or Barrow are transportation hubs, and health centers. As a consequence, loss of services in these communities directly impact surrounding communities.

Percentage of Population Affected. Population affected was rated low if less than 10% of the population would likely be impacted by a threat and rated high if more than 25% of the population would likely be impacted.

Housing Distribution. Housing distribution evaluated the manner by which a community's housing layout could exacerbate damages from a threat. The impact to a spread-out community with a small percentage of housing at risk was rated lower, whereas the impact to a community with a condensed utility corridor at risk was rated higher.

Environmental Threat. Environmental threat addressed the potential or capacity for erosion, flooding, or thawing permafrost to degrade the water quality, and/or increase human exposure to waste. If a community was considered to be in danger of losing a fuel tank or landfill, or of having a wastewater lagoon breached, the threat received a high impact rating.

Cultural Importance. Cultural importance measured threat-related impacts to historically and culturally significant sites such as cemeteries and artifacts. A situation where documented cultural and historic resources are likely to be damaged or lost due to threat received a higher impact rating.

Commercial Infrastructure. Commercial infrastructure involved measuring the impact of a threat on commercial services in the community such as stores, fuel supply, barge landings, and other cash-generating businesses. If a community was in danger of losing its only store, or if the store might close for an extended period of time, that area received a higher impact rating.

Table 4-2. Impact evaluation criteria and their relative impact ratings.

Evaluation Factor	Impact Rating	Justification
Critical Infrastructure (school, utilities, airport, water or fuel storage facilities)	No Impact (0)	• No evidence or likelihood of impact to critical infrastructure due to threat
	Low Impact (1)	• One item of critical infrastructure at risk from threat • Loss of infrastructure would not result in loss of community sustainability • Damage could be repaired, or alternative service restored in less than 1 month
	Medium Impact (2)	• More than one item of critical infrastructure at risk from threat • Loss of infrastructure would not result in loss of community sustainability • Damage could be repaired, or alternative service restored between 1 and 6 months
	High Impact (3)	• More than one item of critical infrastructure at risk from threat • Loss would impact community sustainability • Repairs or establishing alternative service would take more than 6 months
Health and Human Safety (hospital/clinic and emergency services)	No Impact (0)	• No evidence or low likelihood of life safety concerns due to threat
	Low Impact (1)	• Threat unlikely to cause life safety concerns or negatively affect ability to provide emergency services • Community has ability to mitigate or avoid life safety concerns
	Medium Impact (2)	• Only rare threat events would cause life safety concerns or negatively affect ability to provide emergency services • Quick and easy access to emergency services is available
	High Impact (3)	• Threat is likely to result in life safety or affect ability to provide emergency services • Portions or all of the population cut off from emergency services
Subsistence and Shoreline Use (hunting, gathering, processing, and storage)	No Impact (0)	• No evidence or low likelihood of threat affecting subsistence and shoreline use
	Low Impact (1)	• Minor and temporary interruptions of subsistence activities or access to shoreline that are a nuisance but are restored or mitigated in the same year • Damage due to threat could be repaired locally (i.e., repairing boat launch access each spring)
	Medium Impact (2)	• Frequent loss or disruption of subsistence activities or access to shoreline • Critical habitat and/or use areas mild to moderately threatened; traditional practices inconvenienced but not disrupted
	High Impact (3)	• Interruptions of subsistence activities or access to shoreline severe enough to cause impact on continual basis • Critical habitat and/or use areas severely threatened; traditional practices limited to focus on survival

Evaluation Factor	Impact Rating	Justification
Land Use/Geographic Location	No Impact (0)	• Land is readily available in threat-free zones for new development or relocations • Community is located outside of known threat zones
	Low Impact (1)	• Land is available in threat-free zones for new development or relocations • Land use controls in place and/or safe area between existing development and threat zone • Soils and hydrology/hydraulic conditions not conducive to threat • Aggregate resources available locally if mitigation measures needed (for instance, revetment)
	Medium Impact (2)	• Open lands in threat-free zones are limited and future development will likely be in threat zone or significantly alter community footprint • Existing development close to threat zone with some local resources available to assist with mitigation • Soils and hydrology/hydraulic condition conducive to threat
	High Impact (3)	• Open lands are only available in threat zones • Significant damage from threat • Poor soils conducive to erosion and permafrost degradation
Percentage of Population Affected	No Impact (0)	• Threat does not impact the population or housing areas
	Low Impact (1)	• Less than 10% of population affected; alternative housing available
	Medium Impact (2)	• 10 to 25% of population affected; alternative housing available, but limited
	High Impact (3)	• Over 25% of population affected; limited to no alternative housing available
Housing Distribution	No Impact (0)	• Housing distribution does not exacerbate threat
	Low Impact (1)	• Only a few structures and limited associated infrastructure at risk (one-time loss) • Utilities not impacted
	Medium Impact (2)	• Structures in clusters and associated infrastructure at risk with some expected future recurrence of damages • Some impacts to utilities
	High Impact (3)	• Structures in clusters and associated infrastructure at risk with frequent expected future recurrence of damages • Major impacts to utilities
Environmental Threat	No Impact (0)	• Threat does not result in damages to drinking water supply, bulk fuel storage, waste water system, and/or solid waste disposal
	Low Impact (1)	• Minor damages that can be addressed locally through normal operating procedures
	Medium Impact (2)	• Moderate damages that will require limited intervention by an external agency for a limited period

Evaluation Factor	Impact Rating	Justification
	High Impact (3)	• Significant damage that will require extensive intervention by one or more external agencies for an extended period • Damage or loss will impact a percentage of the population's ability to maintain residence • Threat will cause damage that may impact other communities or region, either directly (i.e., upstream contamination) or indirectly (i.e., displaced community members)
Cultural Importance (tanning, carving, dance, art, sports, etc.)	No Impact (0)	• No significant cultural/traditional activities and/or sites impacted by threat
	Low Impact (1)	• Minor or temporary disruption to cultural/traditional activities with no lingering negative impacts • Documented cultural and historic resources may have little to no damage due to threat
	Medium Impact (2)	• Resources required for community to continue with cultural/traditional activities and use of traditional sites • Documented cultural and historic resources may be damaged or lost due to threat • Damages caused by threat exposes previous unknown cultural and historic sites that may be subject to future damages
	High Impact (3)	• Traditional practices abandoned to focus solely on life-safety and survival • Documented cultural and historic resources have been damaged or lost due to threat • Damages caused by threat exposes previous unknown significant cultural and historic sites that are under immediate threat
Commercial Infrastructure (i.e., private enterprise, barge landings, quarries, ports)	No Impact (0)	• Threat does not affect commercial infrastructure • Community is not a hub
	Low Impact (1)	• Temporary impact to operability of commercial infrastructure
	Medium Impact (2)	• Threat has moderate impact on commercial infrastructure associated with overall community cash flow • Impact on commercial infrastructure operability may require external assistance • Loss of commercial infrastructure operability can be temporarily replaced
	High Impact (3)	• Threat has severe effect on commercial infrastructure associated with overall community cash flow • Commercial infrastructure operability is lost, cannot be replaced, and is no longer viable • Community is hub of good/services supporting other communities in region

During the analysis, each of the nine evaluation factors was given relative weighting consistent with the BEA to allow evaluation factors that put a community's viability at greater risk to have a larger influence on the aggregate rating. The highest relative weighting of 3 was applied to Critical Infrastructure, Health and Human Safety, and Environmental Threat. All weightings are shown in Table 4-3.

Table 4-3. Evaluation factors and relative weights.

Evaluation Factor	Relative Weight
Critical Infrastructure	3
Health & Human Safety	3
Subsistence & Shoreline Use	2
Land Use/Geographic Location	1
% Population Affected	2
Housing Distribution	2
Environmental Threat	3
Cultural Importance	1
Commercial Infrastructure	2

Following attribution of an impact rating for each of the nine criteria, those ratings were multiplied by the appropriate relative weight, then summed to form an Aggregate Impact Rating for each individual threat (erosion, flood, thawing permafrost) in each community. Those aggregate impact ratings were then multiplied by a time to damage rating to establish a relative community risk rating for each threat.

4.7 Time to Damage

While evaluating each community for the potential impacts of a threat from erosion, flooding, and thawing permafrost, the expert panel also considered the time to damage. Anticipated damage in the near term indicated a higher urgency than damage that may occur over the long term. For example, rapid erosion that may occur in the next 5 years would likely generate immediate action compared to erosion that occurs slowly over 20 years. In this evaluation, a value of 3 was ascribed to the most urgent threats with short term time to damage, a value of 2 was ascribed to mid-term processes, and a value of 1 was attributed to processes that are expected to impart impacts after a longer period of time.

Factors that informed the time to damage weighting include documented historic losses due to erosion, flooding, or thawing permafrost, such as state or federal disaster declarations. Other documentation used included self-reported damages such as information in the Community Development Plan or Hazard Mitigation Plan. For communities that had ratings pulled from the BEA for erosion risk, first iteration time to damage factors for erosion were also pulled from the BEA.

Mitigation features in the community, such as erosion revetments and levees, were also used to inform time to damage. Communities that have relocated due to devastating damage at an old town site were evaluated based on the time to damage at the current town site. If mitigation features were either temporary or ineffective, the time to damage factors were modified accordingly. Evaluating the time to damage for erosion and flooding was dependent on previously reported issues within the community and through research of available data.

Factors considered in the time to damage for erosion included the BEA, which informed the time to damage assessment for each community evaluated in that study. If new project data indicated that time to damage occurs quicker than the BEA predicted, the rating was adjusted accordingly. For those communities not included in the BEA, the time-to-damage assessment was conducted concurrently with

the flooding time to damage using Hazard Mitigation Plans, Community Development Plans, and news articles.

General guidelines used in the time to damage consideration for flooding included:

- Disaster declarations for a community or region:
    - Three or more disaster declarations set the initial rating to 3 to represent a time-to-damage factor of the community being affected in the short term.
    - One or two disaster declarations set the initial rating to 2 to represent a time-to-damage factor of the community being affected in the mid-term.
    - No disaster declarations set the initial rating to 1 to represent a time-to-damage factor of the community being affected in the long term.
- National Weather Service river notes were reviewed to identify recorded flood events not considered a disaster:
    - If there was evidence that the community had a significant number of smaller floods, the time-to-damage factor was elevated by one rating (e.g., from 1 to 2), not to exceed the short-term rating (3).

The time to damage for thawing permafrost threats was universally attributed with the lowest rating (1) since thawing permafrost is a comparatively slow process, and engineers often have time to take corrective action before catastrophic damage occurs. Both construction of the infrastructure and climate change impact the rate of thawing in permafrost. Impacts due to the construction of infrastructure generally occur much more rapidly than damage resulting as the result of climate change. We note, however, that when thawing permafrost is influenced by erosion and/or flood, the resulting usteq threat could have a much shorter time to damage.

4.8 Calculating Risk and Normalized Scores

This study utilized a risk analysis approach (examination of individual risks from erosion, flooding, and thawing permafrost) across 187 communities throughout the state of Alaska. In the risk analysis, the **Aggregate Impact** ratings estimate the relative nature and magnitude of threat risk in each community, while the **Time to Damage** ratings estimate the likelihood/timing of the expected event. Together, these two factors provide the basis for the community Relative **Risk Rating**. The following relationship was employed to develop the risk rating:

Relative Risk Rating = Aggregate Impact * Time to Damage

The risk ratings above were calculated for the individual threats associated with erosion, flooding, and thawing permafrost. As described previously, however, another goal of this report was to develop an approach for calculating a composite risk rating. This was accomplished by summing the erosion, flooding, and thawing permafrost threats. Since the time to damage rating of the thawing permafrost threat was universally assumed to be 1, however, the highest possible risk rating for permafrost was lower than the highest possible risk ratings for erosion and flood. Thus, without further modification, the permafrost component of the combined rating would exert a comparatively smaller influence on the rating than would erosion or flood. For this reason, the ratings for erosion, flooding, and thawing

permafrost were first normalized using the following equation so that the scale would be consistent between each of the risk factors:

Normalized Score = 100*(Risk Rating/Maximum Possible Rating)

The normalized scores within each threat category are plotted and presented in Figure 5-1 through Figure 5-7. Those normalized scores were also used to order and rank the communities from highest to lowest risk rating. In each category, communities with a rank of 1 were associated with the highest threat level. Note that in some instances, multiple communities had identical normalized scores, and thus were ascribed with identical ranks.

In order to better visualize the distribution of the data, the normalized scores were plotted against the score percentile in Figures 5-1 through 5-4. The percentile was calculated using the following equation:

Score Percentile = (Community Rank Value/Total Number of Discrete Rank Values) * 100

Consideration of the data via the techniques described above provided the means with which to categorize communities into groups associated with high, medium, or low risk to the individual threats of erosion, flooding, or thawing permafrost. It also allowed the study team to characterize the combined threat as the aggregation of the individual threats. Detailed results are presented in Chapter 5.

4.9 Analytical Process Schematic

This chapter described the process by which raw data were evaluated and employed to determine the relative threats imposed by erosion, flood, and thawing permafrost for 187 rural Alaska communities. The process is summarized in Figure 4-1. The figure is intended to represent the generic process applied to each of the three individual threats independently. We note that the combined risk rating, while represented in the process diagram, requires input information from all three threats. As there are numerous steps in the process, this report does not present the intermediate steps on a community level basis. However, that information was provided to the Denali Commission in the form of spreadsheets. In Chapter 5, the normalized community risk rating scores as well as the uncertainty estimates are presented in aggregate in order to provide the readers with a summary of the data distribution and level of uncertainty. The individual community rankings and group designations are presented as maps in Chapter 5 and listed by community in Appendix A.

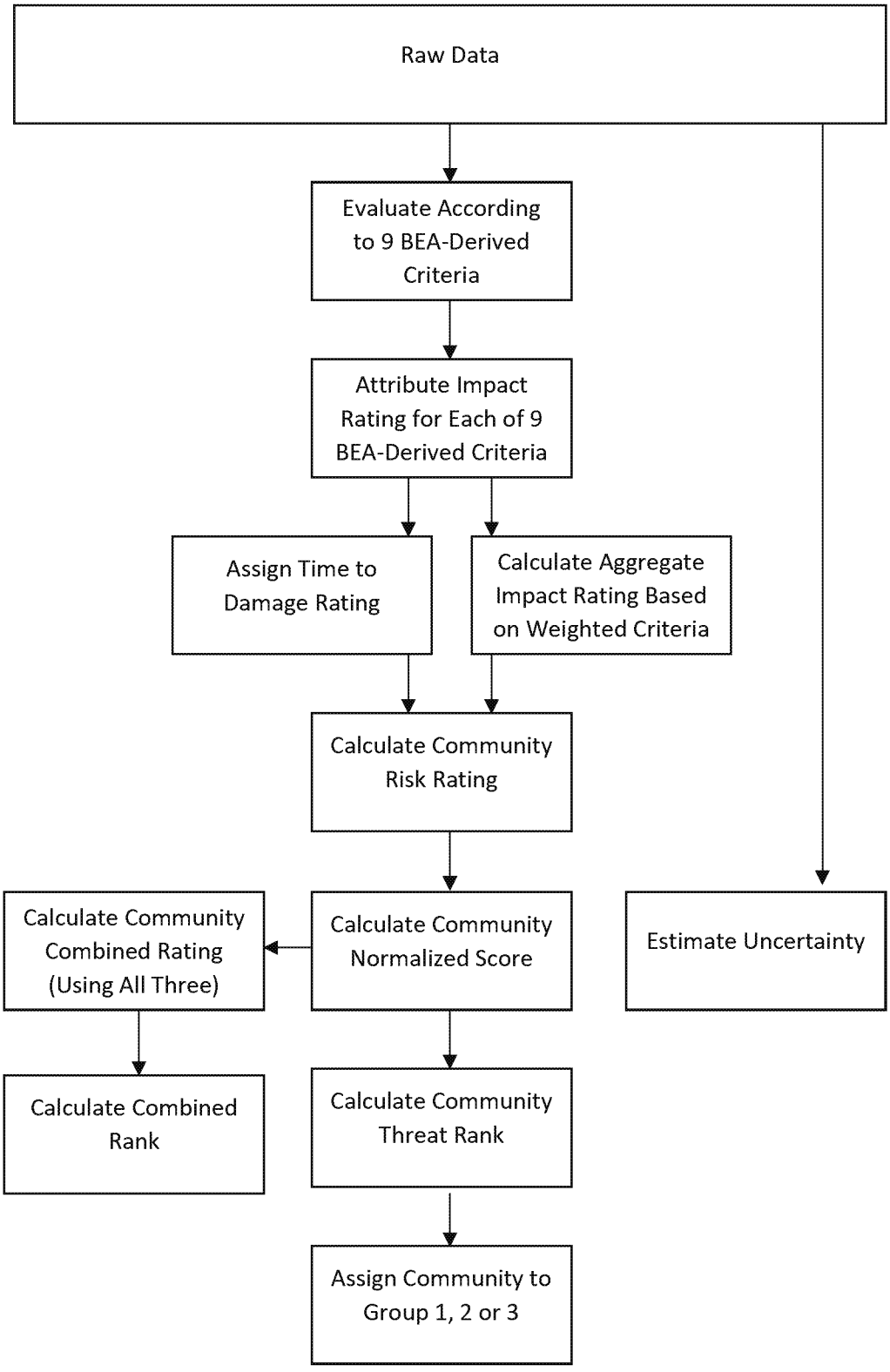

Figure 4-1 Analytical process diagram for evaluating threats from erosion, flood, and thawing permafrost.

4.10 Example of Community Scoring and Ranking

An example of the scoring process is provided here for clarification. For the purpose of this exercise, assume a hypothetical community named MyCommunity which is in Western Alaska and has been scored by the study team using the process described in this report. The scoring for erosion in MyCommunity is provided in Table 4-4.

Scores shown in Column B represent the scores assigned by the study team for each of the nine BEA-derived criteria shown in Column A.

The Impact Ratings in Column B are multiplied by the Factor's Relative Weight to derive the Weighted Impact Ratings shown in Column D. The Relative Weights were obtained from Table 4-3. A summation of the Weighted Impact Ratings results in the Aggregate Impact Rating at the bottom of Column D.

The Time to Damage is short term, so the value assigned is 3. That value is multiplied by the Aggregate Impact Rating to get the Community Risk Rating of 126.

The Normalized Score of 74 is then determined by dividing the Risk Rating by the maximum value for Erosion, 171, and multiplying the result by 100. Comparing the normalized score to the cutoff value of 43, it is determined that MyCommunity lies in Group 1 for erosion. Additional information regarding the development of cutoff values is provided in Sections 5.2 and 5.3.

Figure 5-1 indicates that the erosion threat ranking of MyCommunity would be approximately 23. The ranking is approximate since each time a community is added or altered; the ranking must be updated by including a new community or modifying an existing community and performing the ranking procedures.

This process would then be repeated for flooding and thawing permafrost to determine the Normalized Score for each of MyCommunity's individual threats. The combined score would be the sum of the threat scores for each threat.

Table 4-4. Erosion scoring example for MyCommunity.

A	B	C	D	E	F	G	H
Evaluation Criterion	**Impact Rating**	**Criterion Relative Weight**	**Weighted Impact Rating (B*C)**	**Time to Damage**	**Risk Rating (D*E)**	**Normalized Score (100*(F/ Max Possible Score)**	**Group**
Critical Infrastructure	3	3	9				
Health & Human Safety	2	3	6				
Subsistence & Shoreline Use	1	2	2				
Land Use/Geographic Location	1	1	1				
Population Affected	2	2	4				
Housing Distribution	2	2	4				
Environmental Threat	3	3	9				
Cultural Importance	1	1	1				
Commercial Infrastructure	3	2	6				
Aggregate Ratings			**42**	**3**	**126**	**74**	**Group 1**

Chapter 5.0 Communities at Risk

5.1 Overview

Following development of the normalized community scores and community ranks for each threat, the data were plotted, evaluated, and grouped according to the relative threat level. Communities placed in Group 1 were under the greatest threat from erosion, flood, or thawing permafrost, while communities placed in Group 3 were the least threatened. Group 2 communities were associated with a moderate threat. The distribution of groups is presented in Figure 5-1 through Figure 5-3, and the number of communities within each group is presented in Table 5-1. Note that there are fewer than 187 individual points on those figures because in many cases, an individual point represented an identical score for multiple communities. Criteria for development of each group were based on immediacy, impact, the presence of life safety concerns and required support from outside the region. Those criteria are described more fully in Section 5.2 for erosion and flood threats, and Section 5.3 for the threat of thawing permafrost.

The level of uncertainty associated with the normalized community scores was estimated based largely upon the amount and quality of raw data available. The notion of uncertainty is described more fully in Section 5.4, and the distribution of uncertainty is plotted in Figure 5-4 through Figure 5-6. While uncertainty was not employed as a factor in the calculation of community rankings or groupings, it does provide useful context for the interpretation of results.

No effort was made to parse the combined ranking into groups. Due to the complexity of the threat, the study team did not consider the uncertainty of combined predictions to be comparable to the uncertainty of the report's erosion, flooding, or thawing permafrost threats. However, the combined rankings are useful in identifying those communities which are impacted by multiple threats, thus highlighting the conditions under which usteq may occur. Section 5.5 presents additional information regarding the characterization of usteq, and the ungrouped distribution of normalized combined scores is presented in Figure 5-7.

Section 5.6 presents maps of the community groupings for erosion, flood, and thawing permafrost (see Figure 5-8 through Figure 5-10). In addition, the section provides a map illustrating the distribution of combined rankings across Alaska (Figure 5-11).

5.2 Erosion and Flooding Groupings

The methodology employed to rate the communities by the risk of damages from flooding and erosion was intended to capture the different nature of the two threats. Flooding is typically temporary while erosion is compounding, but one threat does not pose more serious risk to infrastructure than the other. All differences in likelihood and time to damage are captured within the individual risk ratings for each community. As a result, the study team used the same group break points for both flood and erosion. For both, communities with normalized threat scores of 43 or higher were placed into Group 1. Communities with normalized threat scores ranging from 20 through 42 were placed in Group 2, and communities with normalized threat scores below 20 were placed into Group 3. The distribution of these groups is presented in Figure 5-1 and Figure 5-2 for erosion and flooding, respectively.

The designation of the group break points was based largely upon the collective judgment of the study team, as well as upon the distribution of the data. Those break points are visually evident as natural breaks in the curves presented in Figure 5-4 and Figure 5-5. Due to the inherent uncertainties in the analysis, however, a community's group designation should be interpreted as a guide rather than a steadfast descriptor. Communities that fall close to a break point may well merit re-categorization with the addition of more data.

While the impact and time to damage ratings that determined a community's normalized score varied widely from community to community, the members of each threat grouping shared a largely common set of characteristics. The general characteristics of each erosion and flood group are described below:

Group 1 (Erosion and Flooding):
The threat is commonly immediate to critical infrastructure. Damages resulting from a moderate flood or compounding erosion would impact community sustainability, present life safety concerns, affect access to emergency services, and/or require support from outside the region to assist the community in responding to the event. Communities that are included in Group 1 should direct resources towards determining the best response to the threat. Note that a community must have a short or mid-term time to damage rating to be included in Group 1.

Group 2 (Erosion and Flooding):
The threat is not expected to detrimentally impact critical infrastructure in the near term, but the community is still vulnerable to the threat. Damages resulting from a moderate flood or compounding erosion could impact operability for a limited period but would not impact the community's sustainability. An extreme event may cause damages like those described as the impact of a moderate event in Group 1. More research and data collection should be conducted to better understand the threat posed to the community. Note that a community can have a time factor of long or mid-term to be included in Group 2, depending on the severity of damage to critical infrastructure expected if an event occurs.

Group 3 (Erosion and Flooding):
There is no information available that indicates a threat to critical infrastructure or to the viability of a community, or there is low likelihood that a threat will detrimentally impact the community in the near term. If communities in Group 3 experience threats, they should notify officials and collect data to support understanding the impacts. The time to damage is predicted to be long for all communities in Group 3.

5.3 Thawing Permafrost Groupings

Communities threatened by thawing permafrost were grouped by assessing the potential impact of the threat. Included in the assessment were ice content within the soil, the likely distribution of permafrost within the community, the temperature of the permafrost, anticipated thaw settlement, and known problems. Communities with a normalized permafrost threat score of 61 or higher were placed into Group 1. Group 2 was comprised of communities with normalized permafrost threat scores ranging from 42 through 60. Group 3 communities have normalized scores less than 42. The distribution of these groups is presented in Figure 5-3.

Similar to erosion and flooding groups, the communities in each permafrost group tended to share a generally common set of characteristics. These characteristics are described below:

Group 1 (Permafrost):
Risk of damage due to thawing permafrost is high. Ice-rich permafrost is prevalent beneath the community. Thaw settlement is anticipated to be large. Damage to existing infrastructure as a result of thawing permafrost is likely known. The permafrost temperature may be above -2°C but risk of damage also may be extremely high even in the areas with cold permafrost if large near-surface bodies of ground ice (e.g., ice wedges) are affected or may be affected in the future by thermokarst and/or thermal erosion.

Group 2 (Permafrost):
Risk of damage due to thawing permafrost is moderate. Permafrost usually has moderate ice content where thaw settlement is anticipated to be moderate. Reported damage due to thawing permafrost is moderate. Underlying permafrost may be discontinuous.

Group 3 (Permafrost):
Risk of damage due to thawing permafrost is low or nonexistent. Underlying permafrost is sporadic; nonexistent or underlying soils are ice-poor, thaw stable materials such as sandy gravels. No or minor damage has been reported.

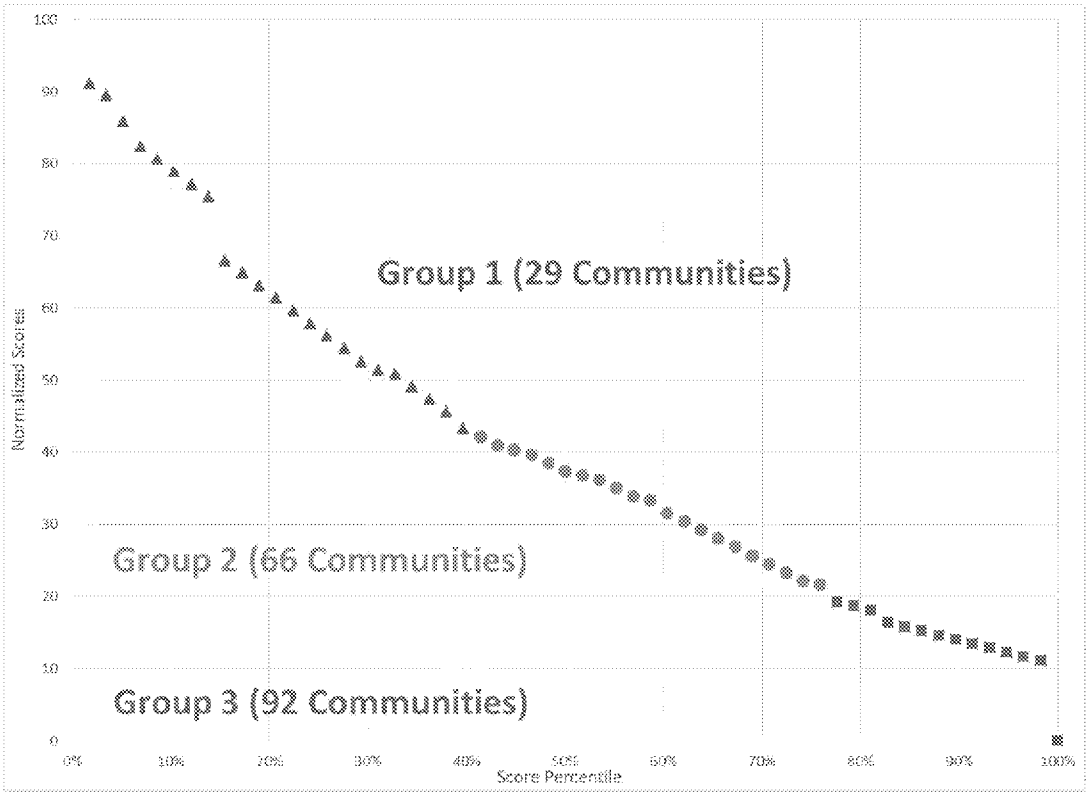

Figure 5-1. Cumulative distribution curve for erosion, illustrating groupings.

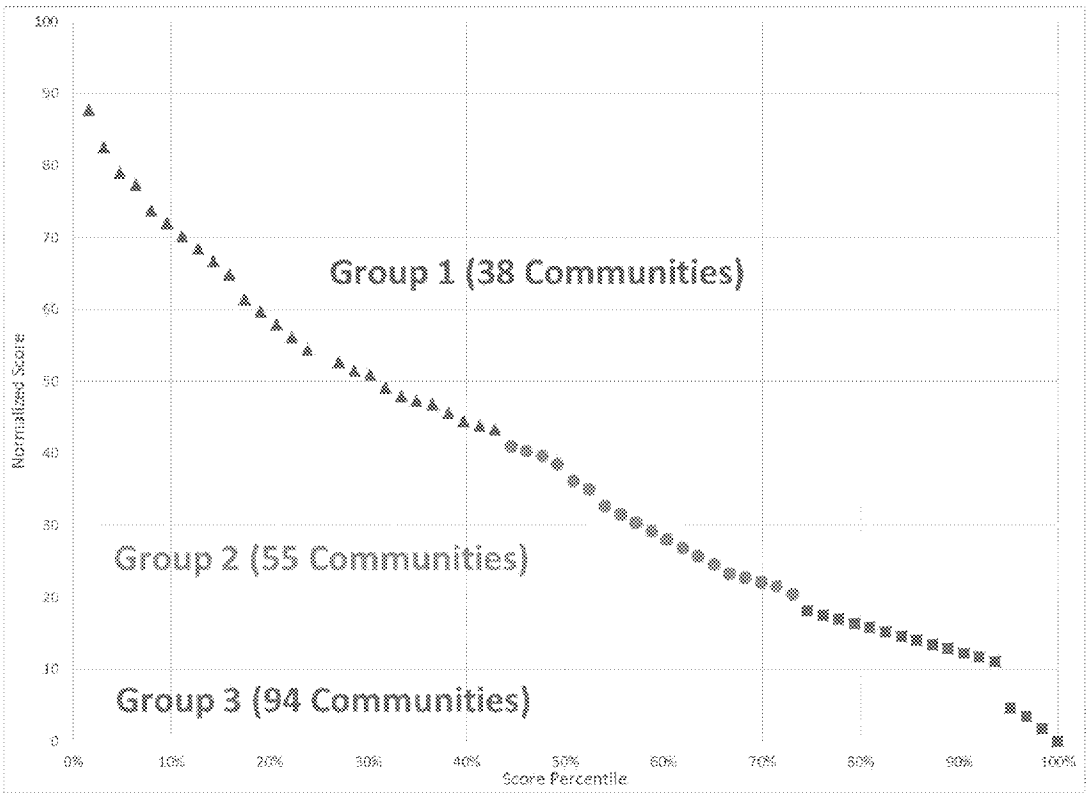

Figure 5-2. Cumulative distribution curve for flooding, illustrating groupings.

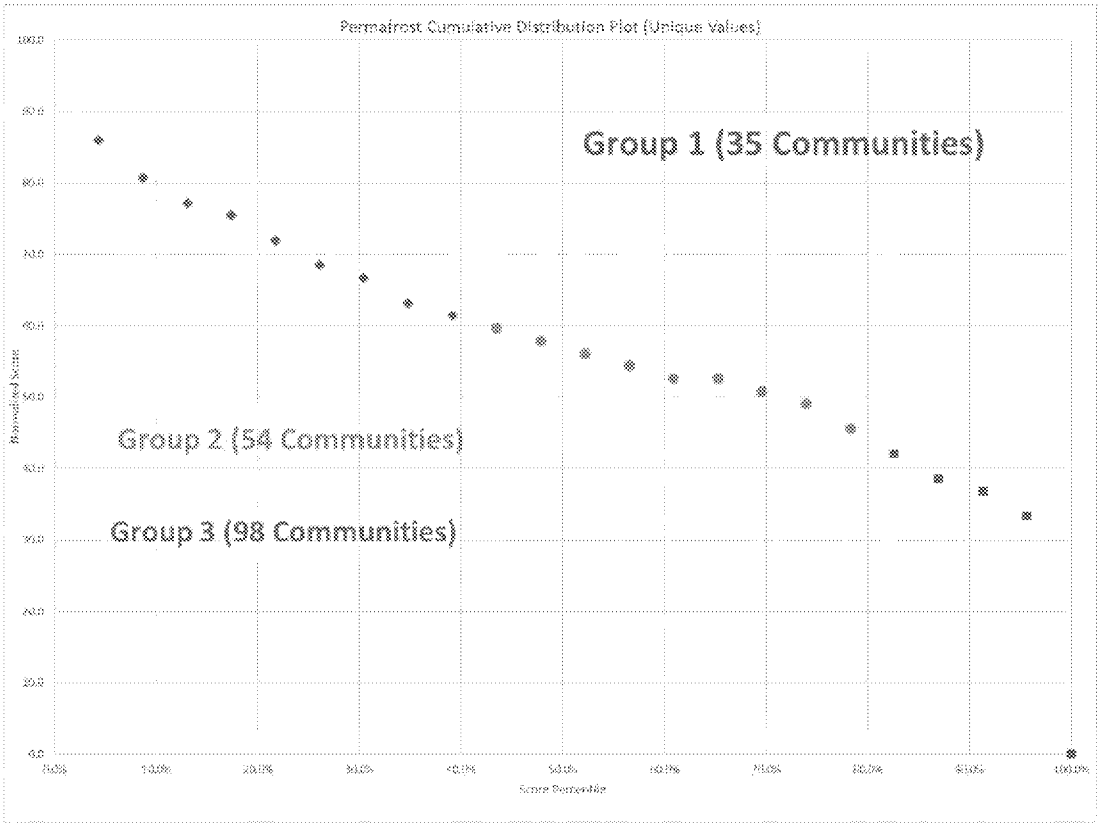

Figure 5-3. Cumulative distribution curve for thawing permafrost, illustrating ratings.

Table 5-1. Number of communities in each group for erosion, flooding, and thawing permafrost.

Communities in Group			
Group	**Erosion**	**Flooding**	**Thawing Permafrost**
Group 1	29	38	35
Group 2	66	55	54
Group 3	92	94	98

5.4 Uncertainty

Uncertainty is directly correlated with the quality and quantity of available data. For each community, an uncertainty "star score" was applied. This method allowed the expert panel to assess communities individually, but to denote any relative uncertainty within the assessment. The uncertainty star scores were converted into percentage of uncertainty. The weighted (excluding time to damage) scores were then multiplied by this percentage to create an uncertainty range for each community. The categories employed to evaluate uncertainty are presented below:

1% (***) Relative high amounts of high-quality data were available.

34% (**) Data were available but lacked either quality or quantity.

67% (*) Relatively little data were available.

Uncertainty does not factor into final groupings. The purpose of including uncertainty estimates in the analysis is to illustrate the point that many communities could potentially fall into a different threat group or be ranked at a different level with the addition of supplementary data.

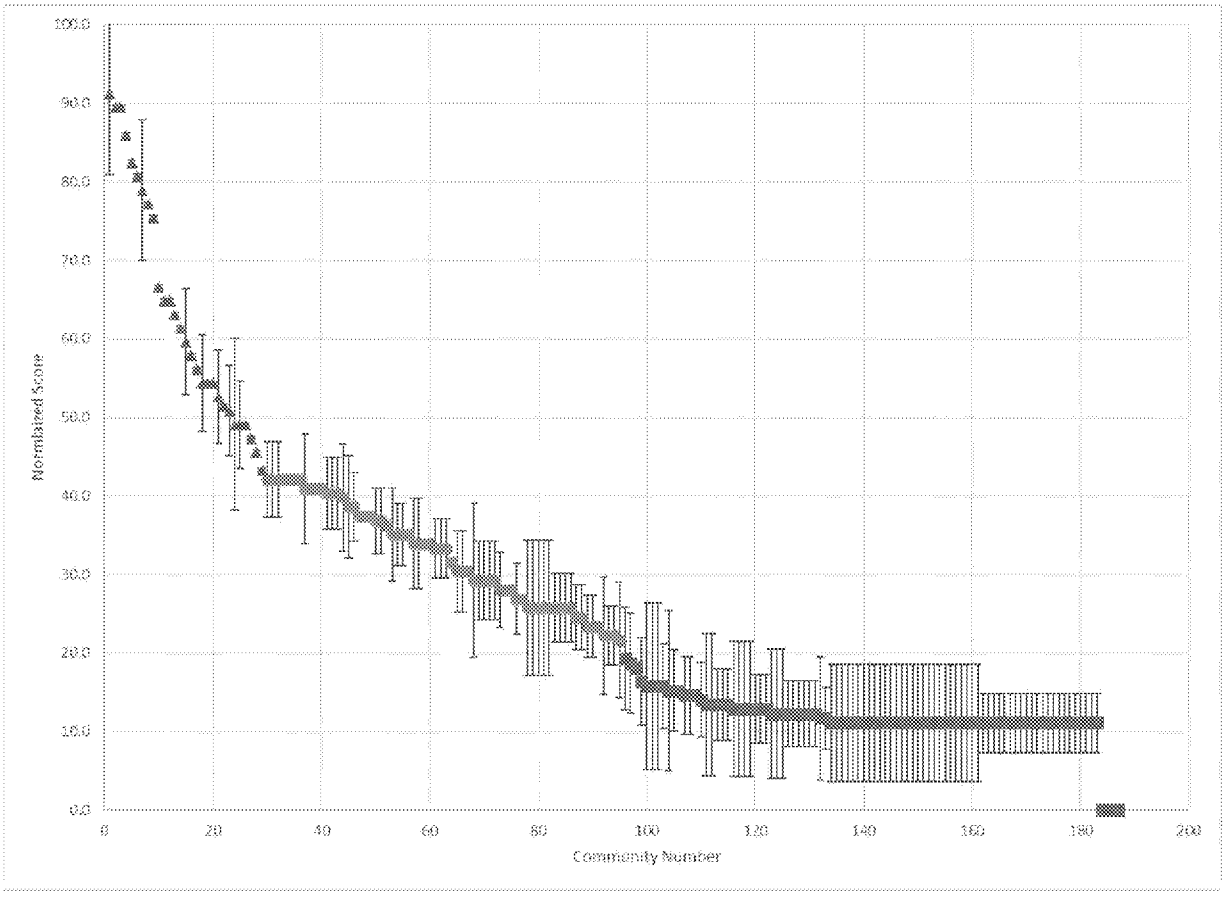

Figure 5-4. Uncertainty estimates associated with erosion.

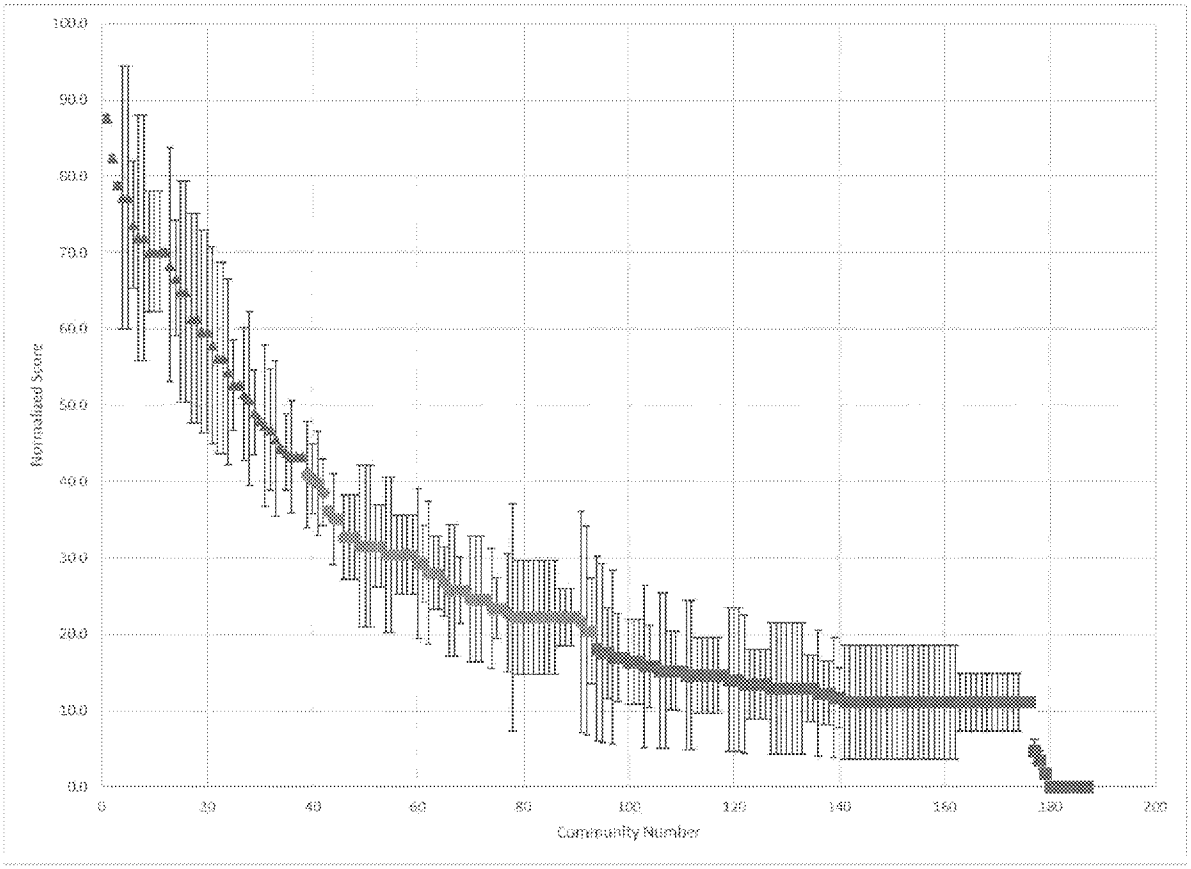

Figure 5-5. Uncertainty estimates associated with flooding.

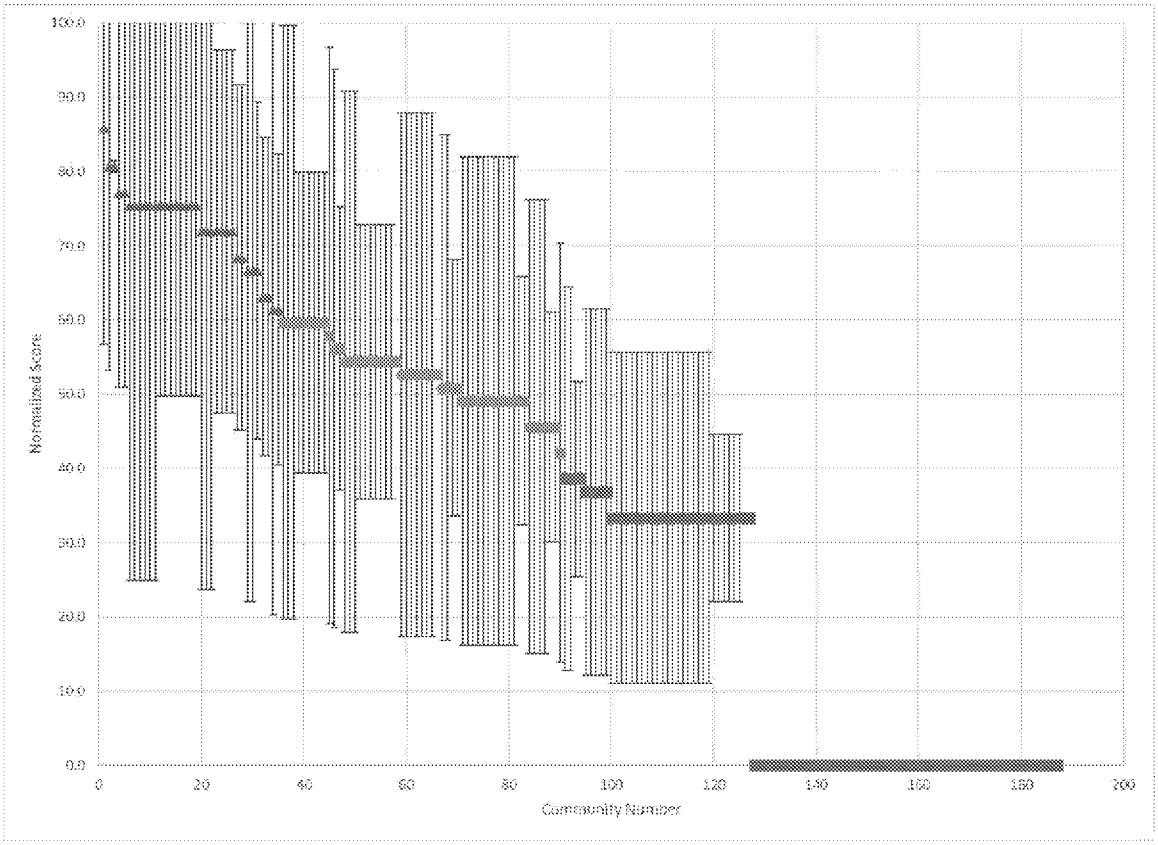

Figure 5-6. Uncertainty estimates associated with thawing permafrost.

5.5 Combined Risk Ratings

Thus far, the focus has been on individual threats. However, it is likely that whenever there are combined threats, the risk of damage may increase because of the escalating feedback between the individual threats. When permafrost is involved, this dynamic has previously been defined as usteq. For example, it is known that permafrost ground ice content is highly heterogeneous, and the amount of ground ice can have a significant effect on the rate of erosion, whether it be massive ice such as observed in ice wedges, or matrix ice binding the soil particles together. There are case studies, including community Hazard Mitigation Plans that document the impacts of usteq, but no literature known to the study team that predicts future processes when erosion, flooding and ice rich permafrost are present. Thus, the characterization of combined risk ratings in this report is not necessarily intended to serve as a predictive tool, but rather as a quantitative description of the conditions under which usteq may occur.

The consensus of the study team was that the ratings of each threat should be added together, though the group recognizes that in some cases this may under-predict the impact of any combination of the threats. However, without additional supporting literature, a simple summation of the normalized threat ratings was deemed appropriate. As described in Section 4.8, scores were normalized prior to summation in order to discount the longer times to damage associated with the permafrost threat alone. When combined with erosion and flood, the permafrost-associated time to damage can be very

short. Figure 5-7 presents a plot illustrating the cumulative distribution of combined ratings for the communities evaluated.

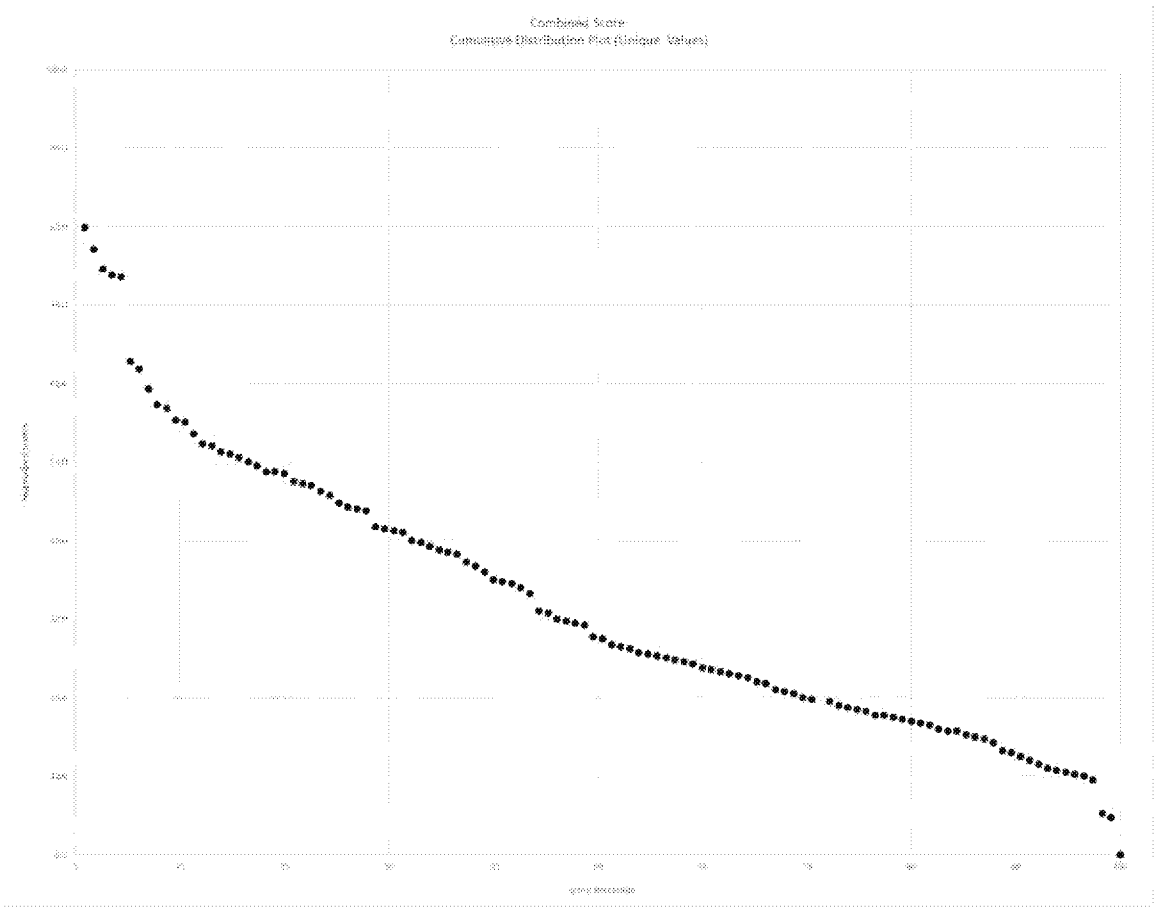

Figure 5-7. Cumulative distribution plot for normalized usteq threat.

The utility and potential drawbacks of the combined ratings are best illustrated through the use of an example. In Figure 5-7, the top five points represent Shaktoolik, Shishmaref, Kivalina, Golovin, and Napakiak. Those communities were attributed with notably higher normalized scores than the other communities. Conspicuously missing is Newtok, which ranks seventh. A closer examination of the individual threat ranking shows Newtok ranks first for the threat of erosion, first for the threat of thawing permafrost, and forty-first for the threat of flooding. Due to its comparatively low score for flood threat, Newtok's resulting combined score was somewhat lower than the top five. However, as noted in Section 4.3, Newtok is clearly impacted by usteq. In Newtok, it is the combination of erosion in ice-rich permafrost that presents an immediate and ongoing threat. While consideration of the combined rating alone would not place Newtok at a higher level of risk compared to the top five, the influence of usteq acts as a driver for Newtok's well-documented erosion threat.

This example illustrates the importance of employing the threat rankings for their intended purpose - to identify those communities that require a detailed investigation of threats from erosion, flooding, and thawing permafrost. The reader is reminded that the groupings of each threat were based on the potential for damage from that threat over time. The combination of threats as represented by the

combined ranking provides some insight into how these threats may combine to accelerate or increase the damage. Consequently, those communities with higher combined scores generally have higher potential for damage.

We recommend that information provided in the individual threat ratings and groupings be used to provide an understanding of the risk due to each threat. The combined score can provide insight into how the threats may compound and when usteq might occur. Using the information, policy makers can determine whether additional data and analysis are required to suggest a course of action.

5.6 Maps

Figure 5-8 through Figure 5-11 provide maps indicating the risk ratings for each community evaluated. These maps provide a regional overview and a means with which to compare an individual community with neighboring communities.

The greatest threat of erosion tends to exist along the western coastline and near the mouth of larger rivers (Figure 5-8). This is consistent with the conclusions of the previous reports. It also confirms the impacts of the loss of early and late season sea ice along Alaska's western coastline.

The vulnerability of communities to flooding is a bit less clear (Figure 5-9). Most communities in Group 1 are located along Yukon and Kuskokwim rivers, or along the coast which may flood due to storm surges. Even so, many of the nearby communities have relatively low vulnerability, likely because they are on higher ground.

The distribution of communities in Group 1 for thawing permafrost tend to be located either along the western coastline or in areas of continuous permafrost (Figure 5-10). At first, this appears to be counterintuitive. One would think that the Interior and the Copper River basin would be more susceptible to risks associated with thawing of ice-rich warm permafrost. However, engineers tend to avoid building on permafrost when possible. As a result, most infrastructure in areas of sporadic or discontinuous permafrost are not found on permafrost at all. Moreover, infrastructure that must be built on warm permafrost is often engineered with the expectation that the permafrost will thaw, thus reducing the threat of damage. At the same time, many communities of Group 1 are located in the areas with cold continuous permafrost. They are included in this group because they experience significant problems related to thawing of large ice wedges that form very close to the surface and therefore are extremely vulnerable to thermokarst (Kanevskiy et al., 2019).

Figure 5-11 provides a map of the combined threat for the communities evaluated in this study. The communities with the greatest combined threat are dark red while the communities with the lowest combined threat are shown in dark green. The color gradient shown in the legend depicts the relative ranking of all communities. As might be expected the communities with the greatest combined threats, and the highest potential for usteq, tend to be along the western coastline. The communities that have a combined threat shown in orange tend to be along the Yukon and lower Kuskokwim Rivers. This roughly corresponds with the Group 2 for erosion, flooding and thawing permafrost threats.

These trends are consistent with the trends published in regional maps that have been produced in other studies, such as Hong (2004). However, the detail provided by these maps illustrates the importance of evaluating each community individually rather than relying upon regional generalizations.

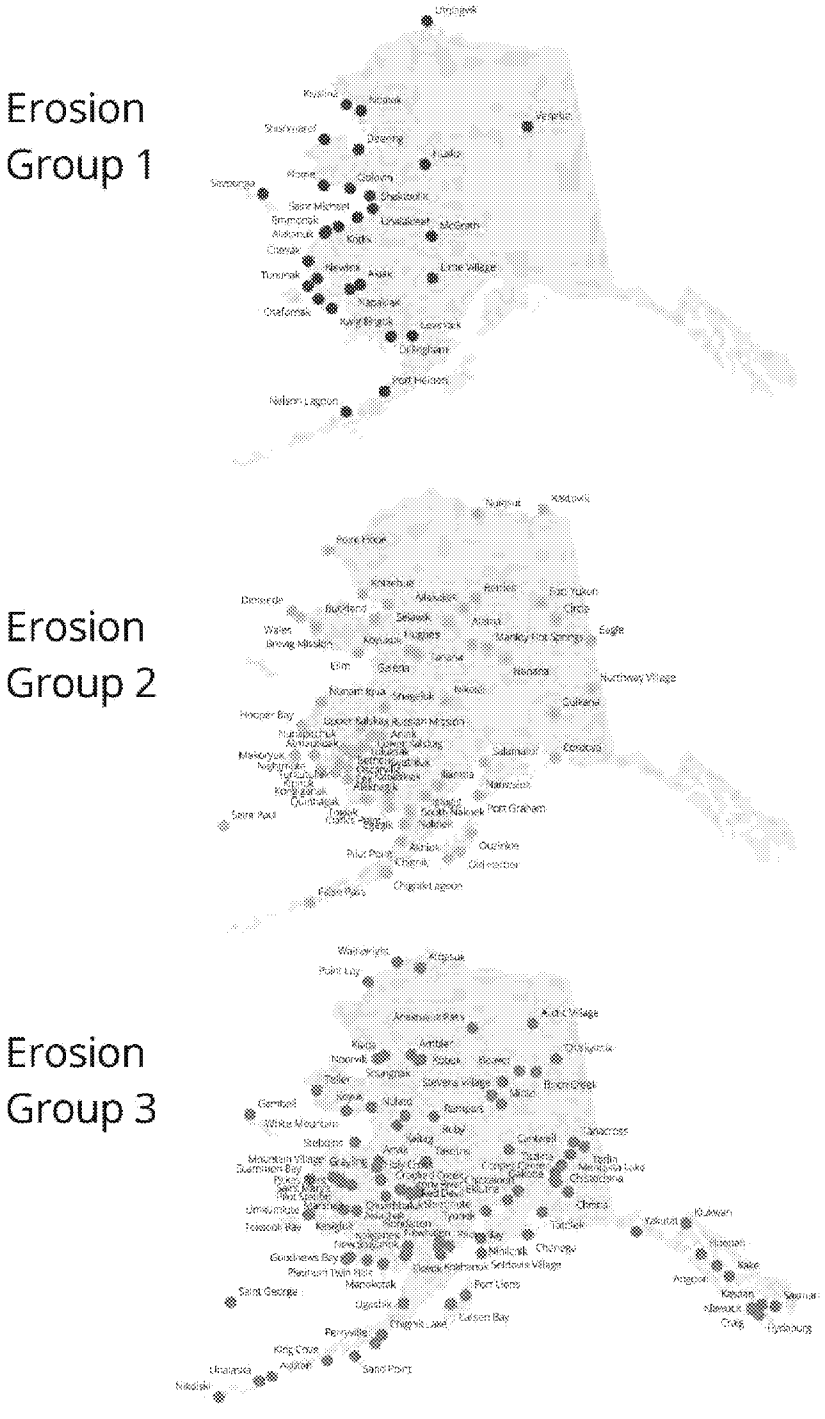

Figure 5-8. Erosion threat risk maps (prepared by Erin Trochim, Alaska Climate Adaptation Science Center).

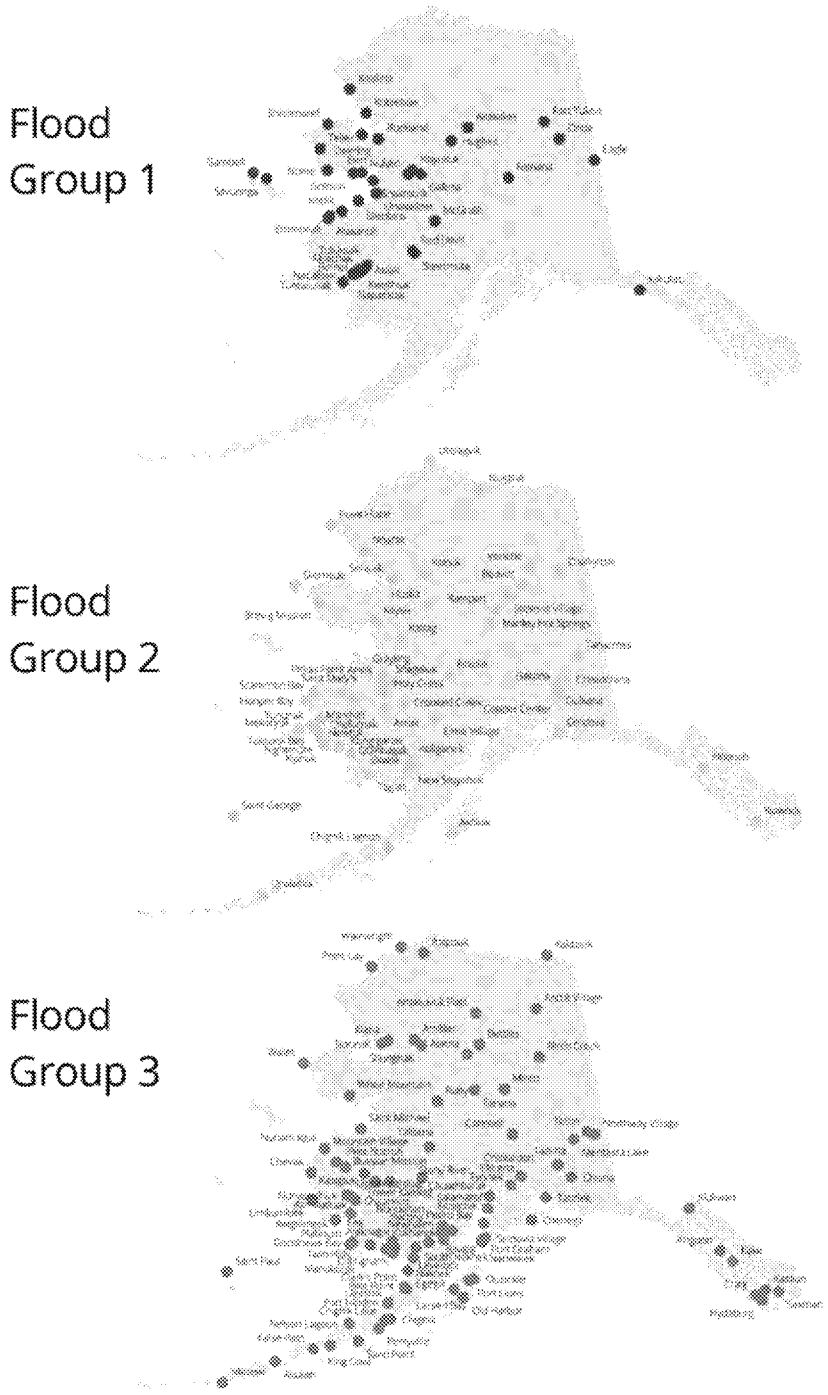

Figure 5-9. Flooding threat risk maps (prepared by Erin Trochim, Alaska Climate Adaptation Science Center).

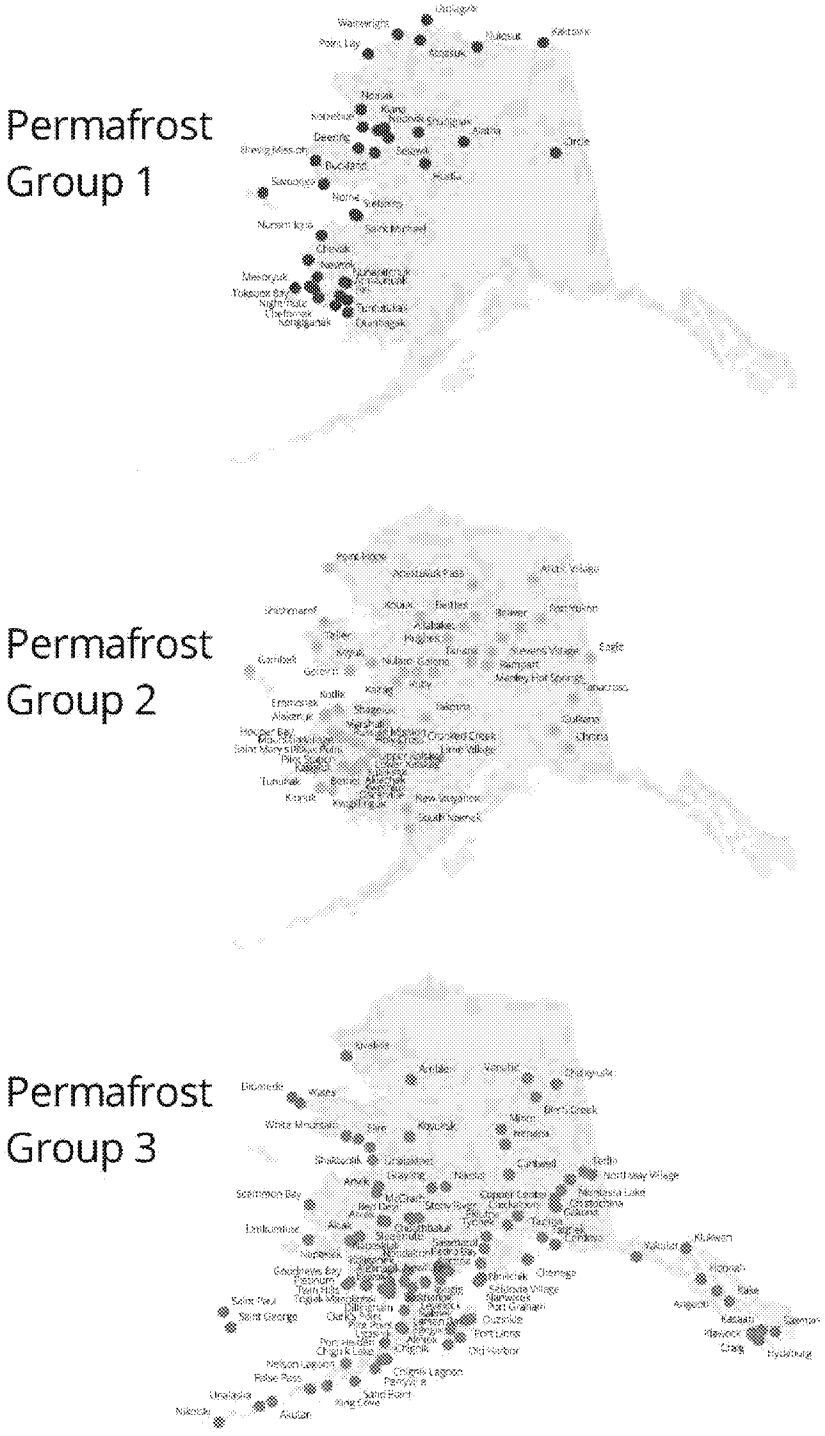

Figure 5-10. Thawing permafrost threat risk maps (prepared by Erin Trochim, Alaska Climate Adaptation Science Center).

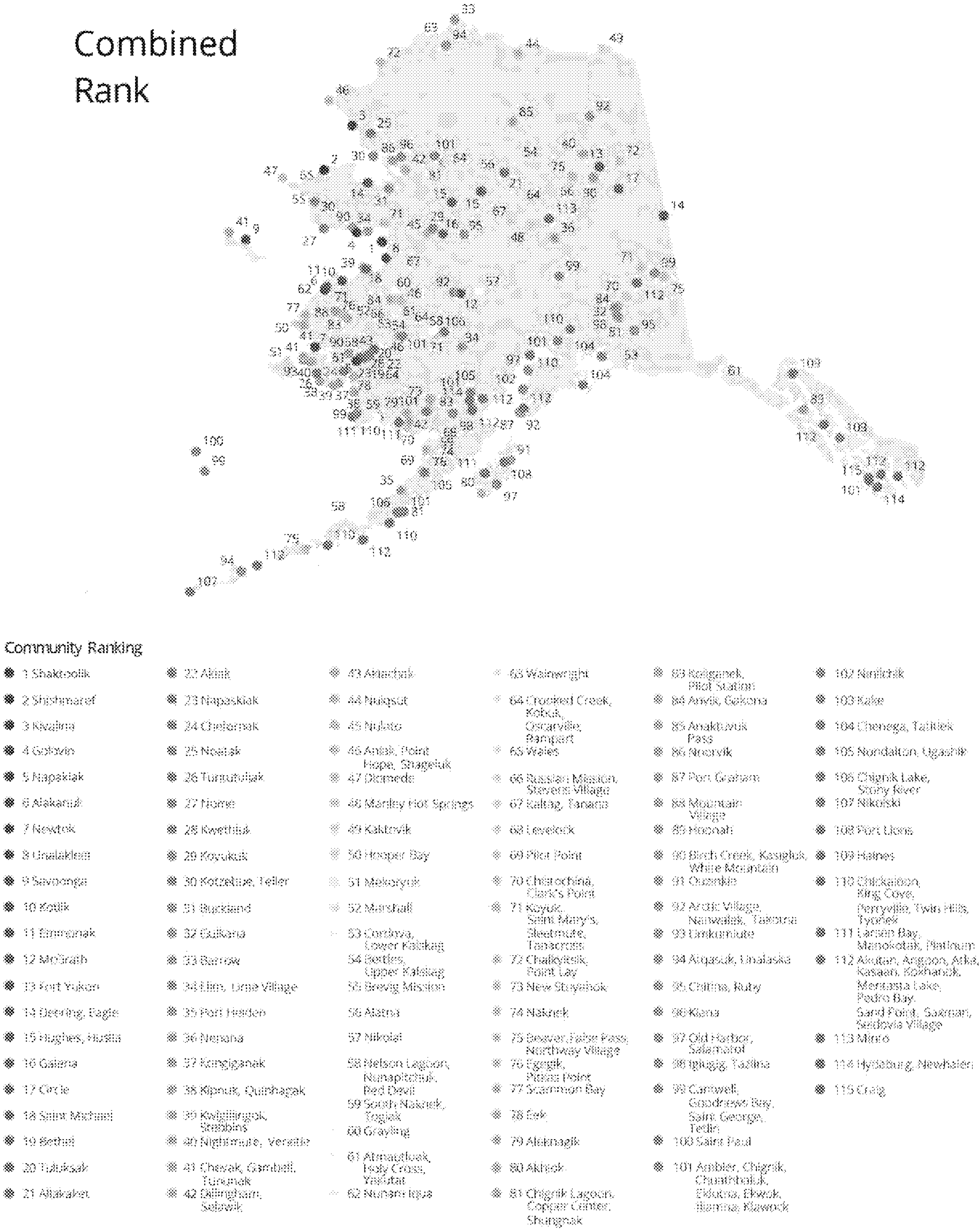

Figure 5-11. Combined threat risk maps (prepared by Erin Trochim, Alaska Climate Adaptation Science Center).

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Chapter 6.0 Recommendations

The purpose of this study was to evaluate the relative risk to rural Alaska communities resulting from erosion, flooding, thawing permafrost and usteq using only existing, readily available data, and to provide guidance regarding how best to measure and further understand those threats. The methodology used protocols developed under the 2009 BEA, with modifications as described in Chapter 4.0.

The data set used in this study will not remain static. As new data become available, the ratings should be periodically updated based on the procedures outlined in this report. The procedures should be reviewed and modified as new data and new knowledge become available, and as new regulations take effect.

It is important that the reader understand that this study does not identify actions necessary to reduce risk due to the rated threats. The study, within the limits of available data, identifies relative risk amongst communities that are facing environmental threats and as a result identifies those that warrant additional analysis to fully understand the nature of the threat and recommend an appropriate course of action. Those communities that are Group 1 due to any of the identified threats should invest additional analysis to parse their community specific threats and identify mitigation actions. If the community is in Group 1 for multiple threats, the data collection plan should account for interaction between the threats.

The following sections describe generalized data collection efforts intended to more fully characterize a threat, or to develop mitigation plans for individual communities. We recommend that federal and state agencies invest in these site-specific studies to aid communities with the development of informed solutions. For instance, such studies would help to evaluate whether it would be more effective for an individual community to relocate, or instead protect in place. Federal and state investment will also help agencies understand the magnitude of the issue in rural Alaska.

The data collection efforts described below should be considered and adopted as appropriate based on existing information and resources available. We recommend the focus be on communities identified as Group 1 communities for each threat and/or for the communities with relatively high combined ratings. It is important that impacts of our changing climate be included in all analyses. Where practical, standards should be established for data collection and analysis to ensure these products are easily compared. Appendices B-D contain suggested scopes of work developed by the Denali Commission to aid communities in the collection of required data. The scopes of work should be modified for each community to capture the data needs of that community. Sections 6-1 through 6-4 provide a suggested list of data elements required for a full analysis of threats and the interaction of those threats.

It is important the community be part of the data collection, analysis and the development of mitigation efforts. Experience has demonstrated that local knowledge provides invaluable information to external planners. Further, the final recommendations require community endorsement.

6.1 Coastal Erosion

Erosion is frequently considered the most critical threat since the consequences are often immediate and typically irreversible. Since the processes for coastal and riparian erosion are different, the recommended next steps will be discussed separately. As discussed in Chapter 3, coastal erosion often occurs in those communities in Western Alaska along the Bering Sea. Wave action, primarily due to fall storms have increased due to the lack of sea ice which has historically protected against the formation of erosive waves. Twenty-two communities located on the west coast have been designated as Group 1 communities threatened by erosion. The following actions are recommended for those communities.

1) Map the existing coastline.
2) Identify the anticipated frequency and severity of storms that may adversely impact those communities. This may be done on a regional basis.
3) Estimate the anticipated water surface elevation for storm surges for the 10%, 4%, 2%, and 1% annual exceedance probability.
4) Estimate erosion for 5, 10, 20 and 30 years into the future considering anticipated changes in climate, sea level rise, tidal data and geology using data available from SNAP at the University of Fairbanks.
5) Identify infrastructure and cultural features that may be adversely impacted.
6) Identify potential mitigation strategies including plans for community growth that reduces those impacts.
7) Update the threat analysis outlined in this report using the data collected

While some of this information is available for some communities, for many, these data are not yet available. When possible an area-wide data collection effort will serve the region. However, when community specific data are required, that data must be collected or estimated. A proposed scope of work which can be used to contract collection of coastal erosion information was prepared by the Denali Commission and can be found in Appendix B.

6.2 Riparian Erosion

Riparian erosion is discussed in Chapter 3. Since Alaskan rivers are generally braided, channels may change rapidly as flows change. The most rapid changes will often occur during periods of increased flow as the result of precipitation, snowmelt, or glacial melt. Prediction of short-term linear erosion rates is relatively straightforward. Prediction of long-term erosion is more difficult; however it is needed in order to inform long term decision making. For example, the maximum extent of predicted erosion will help determine whether a community can mitigate via managed retreat or whether a complete community relocation is required.

1) Map the existing shoreline.
2) Determine historical linear erosion rates and delineate short-term threats to community infrastructure.
3) Identify primary factors driving active erosion (geomorphic and anthropogenic).
4) Estimate flows and velocities at which significant erosion occurs. Note these may be lower than those occurring at flood stage.

5) Identify the annual exceedance probability of these flows.
6) Establish long-term erosion projections based on hydrologic and hydraulic modeling for 5, 10, 20 and 30-year horizons.
7) Identify infrastructure and cultural features that may be impacted.
8) Evaluate the effectiveness and feasibility of structural mitigation measures (barriers and bank stabilization)
9) Evaluate the relative efficacy of non-structural mitigation measures (e.g. managed retreat away from erosion threat) in comparison to structural measures.
10) Determine the long-term viability of the current community site based on model projections.
11) Develop recommendations for both near-term and long-term mitigation measures.
12) Update the threat analysis outlined in this report using the data collected

A proposed scope of work which can be used to contract collection of riparian erosion and flooding information was prepared by the Denali Commission and can be found in Appendix C.

6.3 Flooding

While the exact timing of flooding cannot be predicted, the chances of flooding occurring in any given year can be estimated. The probability of exceeding a specified water surface elevation due to a flood event in any given year is referred to as an annual exceedance probability. Associating the water surface elevation with the annual exceedance probability allows one to relate damage in the community and where that damage may occur. The following recommendations relate to the completion of an analysis to evaluate flood water surface elevation and return period.

1) Collect bathymetric or river cross-section data for the area of interest.
2) Establish a tidal determination for tidally influenced areas or a base flow elevation for interior rivers.
3) Estimate frequency and severity of storm systems and analyze wave dynamics.
4) Estimate relative sea level rise.
5) Utilizing hydrodynamic modeling, estimate the water surface elevation for return periods of the 10%, 4%, 2%, and 1% annual exceedance probability and develop flood maps for each annual exceedance probability.
6) Identify infrastructure and cultural features that will be impacted by elevated water events.
7) Develop a community plan that recognizes these events. Note that the water elevation of concern may vary for different infrastructure. For example, minor drainage structures may be designed for water levels associated with the 10% annual exceedance probability, while major drainage structures may be designed for water levels associated with the 4% or 2% annual exceedance probability. Critical infrastructure such as schools, clinics, and airports should be located above the water elevation associated with the 1% annual exceedance probability.
8) Determine the long-term viability of the current community site based on model projections.
9) Develop recommendations for both near-term and long-term mitigation measures. Identify mitigation strategies that minimize the impact of flooding. This may include improvements to

drainage, protective embankments, establishment of minimum first floor elevations for structures and/or other flood proofing measures, etc.

10) Update the threat analysis outlined in this report using the data collected.

A proposed scope of work which can be used to contract for the collection of storm surge flooding information was prepared by the Denali Commission and can be found in Appendix B.

6.4 Thawing Permafrost

Evaluation of threats from thawing permafrost is the most data intensive of the three threats because of the spatial variation of soil profiles at many sites. This is the reason geotechnical investigations are required for each public building. Geotechnical data for linear infrastructure, such as roads and airports or utility distribution systems, are generally collected in sufficient detail to characterize segments along the route. Nonetheless, there are still numerous instances in which sufficient geotechnical data have not been collected. Moreover, it is unrealistic to assume the burden of such detailed data collection efforts for all existing infrastructure. However, it is realistic to perform an inventory of the infrastructure to record existing distress and to identify potential future damage. If geotechnical data are available, the data should be included in the analysis. If additional geotechnical data is required, the collection of that information should be tied to a specific purpose.

Detailed understanding of the threat from thawing permafrost requires that a qualified team inspect the infrastructure site. It is suggested that the following data be collected and analyzed.

1) Develop and implement a community geotechnical investigation plan that will incorporate existing geotechnical data along with geophysical data to characterize the soil profiles in the community. The purpose is to identify those areas which contain ice rich permafrost and the location of ice wedges which will likely have sufficient thaw consolidation or loss of bearing capacity that may adversely impact current or future structures. The plan may include soil profile data from drilling, pits and geophysical investigations. The proposed geotechnical investigation plan should be limited only to those data which are necessary to assess the impact of thawing permafrost on the community infrastructure. The plan should include all existing geotechnical data, satellite and aerial photography, and terrain analysis.
2) Inspect public infrastructure and a sampling of residential structures to identify distress related to permafrost. The distress should be characterized as cosmetic, functional or structural. Structural and functional distress may require immediate mitigation due to safety concerns or loss of function, whereas cosmetic distress may be lower priority. Identify the causes of distress including whether the distress is due to poor design/construction or due to changing climate during the life of the structure.
3) Identify the foundation type noting any distress and potential distress in the foundation such as settlement, rotation or loss of bearing capacity.
4) Identify areas of drifting snow, ponded water or drainage features, impacts of structures including utilities or roadways, or any other man-made features which may contribute to thawing of permafrost.

5) Characterize the impacts of climate change over the next 10- and 50-year horizon on thawing permafrost and the potential interaction with engineered features.
6) Identify primary factors driving active permafrost thaw (climactic and anthropogenic).
7) Identify non-structural practices that can be locally implemented to slow or check destructive permafrost thaw.
8) Recommend types of structures and foundations appropriate for these areas.
9) Identify potential community expansion areas which minimize the potential for adverse impacts on infrastructure over the next 50 years.
10) Update the threat analysis outlined in this report using the data collected.

A proposed scope of work which can be used to contract collection of permafrost data was prepared by the Denali Commission and can be found in Appendix D.

6.5 Combined Rankings

The combined ranking is useful for illustrating that a threat exists, and a detailed evaluation is necessary. If the community is at the top of the ranking, there is a high probability that the community is facing multiple threats. For example, Shaktoolik, the community with the highest combined risk rank, is threatened by erosion (ranked 3) and flooding (ranked 1). While there is permafrost in Shaktoolik, the community falls into Group 3 (ranked 20) indicating a relatively low threat. Consequently, data collection efforts should focus on flooding and erosion, with recognition that permafrost may or may not play a role.

This study does not provide recommendations for further data collection or analysis regarding the combined threat as a stand-alone threat. Instead, the potential for damage resulting from combined threats should be assessed on a site-specific basis.

6.6 Final Comments

This document provides a threat evaluation for public infrastructure in 187 rural Alaska communities, as well as guidance for further investigation. The data collection, analysis, and reporting suggested above are intended to serve as a guideline rather than a prescriptive list. Each community is unique due to the geology, hydrology, community layout, and other factors. Consequently, these efforts must be tailored to the community.

As described in the introduction to this report, the study team utilized readily available data to conduct the analyses and did not conduct site visits as part of the study. Detailed community evaluations will require onsite investigations and collection of additional data. We recommend that federal and state agencies commit funding to support practical site-specific research in those communities determined to be most highly threatened. Example scopes of work for such investigations are provided in Appendix B-D.

Several ancillary efforts are ongoing, including identification of communities in peril by the State of Alaska, evaluation of the impact of climate change on erosion, flooding, and thawing permafrost,

development of Hazard Mitigation Plans, and economic impacts of environmental threats. Interest in the data set and analysis produced as part of this study is considerable.

A central repository for community specific data would help community planners, engineers and scientists develop community plans, design resilient infrastructure and to understand the relationships between the environment and those living in that environment. Coupled with climate data, user groups will be better able to adapt to the environment of the future.

In order for such a data repository to reach its full potential, standardization of data collection methodology and terminology is necessary. Appendices B-D provide possible templates for additional data sets required for a full understanding of the risk of damage due to erosion, flooding and thawing permafrost.

As a starting point, the geospatial data employed for this study are being made available in the Arctic Data Collaborative database hosted by UAF Scenarios Network for Alaska + Arctic Planning (SNAP). We recommend that this information be incorporated into a managed and updated public data repository to serve as the basis for planning and design tools useful for mitigating threats to rural Alaska's infrastructure.

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Appendix A – Risk Assessment of Alaska Communities

Listed here are the communities sorted by group for each threat: erosion, flooding, and permafrost. The communities within each group are listed by their rank based on the normalized score and listed alphabetically for the convenience of the reader. The rankings of the combined scores are also listed by rank and alphabetically. The reader is encouraged to read the report to understand how the rankings and groupings were derived and to gain insight into their meaning.

Erosion Rankings

Table A-1. Erosion Group 1 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(1) Newtok	(8) Saint Michael	(14) Kwigillingok	(19) Nelson Lagoon
(2) Kivalina	(9) Chefornak	(15) McGrath	(20) Barrow
(2) Napakiak	(10) Huslia	(16) Akiak	(20) Tununak
(3) Shaktoolik	(10) Savoonga	(16) Alakanuk	(20) Venetie
(4) Shishmaref	(11) Kotlik	(16) Lime Village	(21) Emmonak
(5) Port Heiden	(12) Dillingham	(17) Chevak	(22) Levelock
(6) Unalakleet	(13) Noatak	(18) Deering	(23) Nome
(7) Golovin			

Table A-2. Erosion Group 1 (alphabetical with ranking indicated).

(16) Akiak	(7) Golovin	(15) McGrath	(8) Saint Michael
(16) Alakanuk	(10) Huslia	(2) Napakiak	(10) Savoonga
(20) Barrow	(2) Kivalina	(19) Nelson Lagoon	(3) Shaktoolik
(9) Chefornak	(11) Kotlik	(1) Newtok	(4) Shishmaref
(17) Chevak	(14) Kwigillingok	(13) Noatak	(20) Tununak
(18) Deering	(22) Levelock	(23) Nome	(6) Unalakleet
(12) Dillingham	(16) Lime Village	(5) Port Heiden	(20) Venetie
(21) Emmonak			

Table A-3. Erosion Group 2 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(24) Evansville	(29) Bethel	(35) Galena	(40) Northway
(24) Fort Yukon	(29) Kalskag (Lower)	(36) Port Graham	(40) Old Harbor
(24) Gulkana	(29) Kotzebue	(36) Shageluk	(40) Russian Mission
(24) Kaktovik	(30) Aleknagik	(36) Wales	(40) Salamatoff
(24) Kwethluk	(30) Circle	(37) Naknek	(40) Tanana
(24) Pilot Point	(31) Nanwalek	(37) Napaskiak	(40) Tuluksak
(24) Point Hope	(32) Diomede	(37) Nuiqsut	(41) Brevig Mission
(25) Clarks Point	(32) Hughes	(37) Oscarville	(41) Eek
(25) Nunapitchuk	(32) Kalskag (Upper)	(37) Ouzinkie	(42) Koyukuk
(25) Selawik	(32) Kongiganak	(38) Alatna	(42) Saint Paul Island
(25) Tuntutuliak	(33) Eyak	(38) Elim	(42) Nunam Iqua
(26) Aniak	(33) Igiugig	(38) Mekoryuk	(43) Akhiok
(26) Hooper Bay	(33) Nightmute	(39) Buckland	(43) Allakaket
(26) Kipnuk	(33) South Naknek	(39) Eagle	(43) Chignik Bay
(27) Egegik	(34) Iliamna	(40) Atmautluak	(44) Togiak
(28) False Pass	(34) Manley Hot Springs	(40) Chignik Lagoon	
(28) Quinhagak	(34) Nenana	(40) Nikolai	

Table A-4. Erosion Group 2 (alphabetical with ranking indicated).

(43) Akhiok
(38) Alatna
(30) Aleknagik
(43) Allakaket
(26) Aniak
(40) Atmautluak
(29) Bethel
(41) Brevig Mission
(39) Buckland
(43) Chignik Bay
(40) Chignik Lagoon
(30) Circle
(25) Clarks Point
(32) Diomede
(39) Eagle
(41) Eek
(27) Egegik
(38) Elim
(24) Evansville
(33) Eyak
(28) False Pass
(24) Fort Yukon
(35) Galena
(24) Gulkana
(26) Hooper Bay
(32) Hughes
(33) Igiugig
(34) Iliamna
(29) Kalskag (Lower)
(32) Kalskag (Upper)
(24) Kaktovik
(26) Kipnuk
(32) Kongiganak
(29) Kotzebue
(42) Koyukuk
(24) Kwethluk
(34) Manley Hot Springs
(38) Mekoryuk
(37) Naknek
(31) Nanwalek
(37) Napaskiak
(34) Nenana
(33) Nightmute
(40) Nikolai
(40) Northway
(37) Nuiqsut
(42) Nunam Iqua
(25) Nunapitchuk
(40) Old Harbor
(37) Oscarville
(37) Ouzinkie
(24) Pilot Point
(24) Point Hope
(36) Port Graham
(28) Quinhagak
(40) Russian Mission
(42) Saint Paul Island
(40) Salamatoff
(25) Selawik
(36) Shageluk
(33) South Naknek
(40) Tanana
(44) Togiak
(40) Tuluksak
(25) Tuntutuliak
(36) Wales

Table A-5. Erosion Group 3 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(45) Wainwright
(46) Teller
(47) Yakutat
(48) Ninilchik
(49) Birch Creek
(49) Toksook Bay
(49) White Mountain
(50) Kake
(50) Red Devil
(50) Stebbins
(51) Gambell
(51) New Stuyahok
(51) Tatitlek
(52) Port Lions
(53) Atqasuk
(53) Marshall
(53) Noorvik
(53) Nulato
(53) Stevens
(54) Akiachak
(54) Chickaloon
(54) Kiana
(54) King Cove
(54) Nikolski
(54) Saint George Island
(54) Unalaska
(55) Chignik Lake
(55) Chistochina
(55) Kobuk
(55) Koyuk
(55) Larsen Bay
(55) Manokotak
(55) Point Lay
(55) Saint Mary's
(55) Ugashik
(56) Copper Center
(56) Platinum
(57) Akutan
(57) Ambler
(57) Anaktuvuk
(57) Angoon
(57) Anvik
(57) Arctic
(57) Atka
(57) Beaver
(57) Cantwell
(57) Chalkyitsik
(57) Chenega Bay
(57) Haines
(57) Chitina
(57) Chuathbaluk
(57) Crooked Creek
(57) Eklutna
(57) Ekwok
(57) Gakona
(57) Goodnews Bay
(57) Grayling
(57) Holy Cross
(57) Hoonah
(57) Kaltag
(57) Kasaan
(57) Kasigluk
(57) Klawock
(57) Kokhanok
(57) Mountain Village
(57) New Koliganek
(57) Newhalen
(57) Nondalton
(57) Pedro Bay
(57) Perryville
(57) Pilot Station
(57) Pitka's Point
(57) Rampart
(57) Ruby
(57) Sand Point
(57) Saxman
(57) Scammon Bay
(57) Seldovia
(57) Shungnak
(57) Sleetmute
(57) Stony River
(57) Takotna
(57) Tanacross
(57) Tazlina
(57) Tetlin
(57) Twin Hills
(57) Tyonek
(58) Craig
(58) Hydaburg
(58) Mentasta
(58) Minto

Table A-6. Erosion Group 3 (alphabetical with ranking indicated). Table C-6. Group 3 (alphabetical with ranking indicated).

(54) Akiachak
(57) Akutan
(57) Ambler
(57) Anaktuvuk
(57) Angoon
(57) Anvik
(57) Arctic
(57) Atka
(53) Atqasuk
(57) Beaver
(49) Birch Creek
(57) Cantwell
(57) Chalkyitsik
(57) Chenega Bay
(54) Chickaloon
(55) Chignik Lake
(57) Haines
(55) Chistochina
(57) Chitina
(57) Chuathbaluk
(56) Copper Center
(58) Craig
(57) Crooked Creek
(57) Eklutna
(57) Ekwok
(57) Gakona
(51) Gambell
(57) Goodnews Bay
(57) Grayling
(57) Holy Cross
(57) Hoonah Indian
(58) Hydaburg
(50) Kake
(57) Kaltag
(57) Kasaan
(57) Kasigluk
(54) Kiana
(54) King Cove
(57) Klawock
(55) Kobuk
(57) Kokhanok
(55) Koyuk
(55) Larsen Bay
(55) Manokotak
(53) Marshall
(58) Mentasta
(58) Minto
(57) Mountain Village
(57) New Koliganek
(51) New Stuyahok
(57) Newhalen
(54) Nikolski
(48) Ninilchik
(57) Nondalton
(53) Noorvik
(53) Nulato
(57) Pedro Bay
(57) Perryville
(57) Pilot Station
(57) Pitka's Point
(56) Platinum
(55) Point Lay
(52) Port Lions
(57) Rampart
(50) Red Devil
(57) Ruby
(54) Saint George Island
(55) Saint Mary's
(57) Sand Point
(57) Saxman
(57) Scammon Bay
(57) Seldovia
(57) Shungnak
(57) Sleetmute
(50) Stebbins
(53) Stevens
(57) Stony River
(57) Takotna
(57) Tanacross
(51) Tatitlek
(57) Tazlina
(46) Teller
(57) Tetlin
(49) Toksook Bay
(57) Tyonek
(57) Twin Hills
(55) Ugashik
(54) Unalaska
(45) Wainwright
(49) White Mountain
(47) Yakutat

Flood Rankings

Table A-7. Flood Group 1 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat rating.

(1) Shaktoolik	(7) Napakiak	(13) Gambell	(22) Kwethluk
(2) Shishmaref	(7) Napaskiak	(14) Akiachak	(23) Unalakleet
(3) Eagle	(8) Galena	(14) Elim	(24) Kotzebue
(4) Alakanuk	(9) Teller	(15) Kotlik	(25) Nome
(4) Golovin	(10) Emmonak	(17) Nulato	(26) Savoonga
(5) Tuluksak	(10) Fort Yukon	(17) Stebbins	(27) Sleetmute
(6) Allakaket	(11) Circle	(18) Nenana	(27) Tuntutuliak
(6) Kivalina	(11) McGrath	(19) Buckland	(27) Yakutat
(7) Hughes	(12) Akiak	(20) Red Devil	
(7) Koyukuk	(12) Bethel	(21) Deering	

Table A-8. Flood Group 1 (alphabetical with ranking indicated). Table C-8. Group 1 (alphabetical with ranking indicated).

(14) Akiachak	(10) Emmonak	(22) Kwethluk	(2) Shishmaref
(12) Akiak	(10) Fort Yukon	(11) McGrath	(27) Sleetmute
(6) Allakaket	(8) Galena	(7) Napakiak	(17) Stebbins
(4) Alakanuk	(13) Gambell	(7) Napaskiak	(9) Teller
(12) Bethel	(4) Golovin	(18) Nenana	(5) Tuluksak
(19) Buckland	(7) Hughes	(25) Nome	(27) Tuntutuliak
(11) Circle	(6) Kivalina	(17) Nulato	(23) Unalakleet
(21) Deering	(15) Kotlik	(20) Red Devil	(27) Yakutat
(3) Eagle	(24) Kotzebue	(26) Savoonga	
(14) Elim	(7) Koyukuk	(1) Shaktoolik	

Table A-9. Flood Group 2 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(28) Togiak	(35) Nuiqsut	(40) Noatak	(44) Chefornak
(29) Gulkana	(36) Aniak	(40) Scammon Bay	(44) Ekwok
(30) Grayling	(36) Holy Cross	(40) Unalaska	(44) Gakona
(31) Marshall	(36) Hoonah	(41) Akhiok	(44) Klawock
(32) Eyak	(36) Kobuk	(41) Newtok	(44) Koyuk
(33) Diomede	(36) Rampart	(41) Toksook Bay	(44) Mekoryuk
(33) Shageluk	(36) Venetie	(41) Saint Mary's	(44) New Koliganek
(34) Huslia	(37) Quinhagak	(42) Copper Center	(44) New Stuyahok
(34) Kipnuk	(37) Manley Hot Springs	(42) Point Hope	(44) Pitka's Point
(34) Kongiganak	(38) Kaltag	(42) Selawik	(44) Saint George Island
(35) Chalkyitsik	(38) Nikolai	(43) Tununak	(45) Barrow
(35) Chistochina	(38) Stevens	(44) Anvik	(46) Chignik Lagoon
(35) Crooked Creek	(39) Tanacross	(44) Beaver	(46) Hooper Bay
(35) Nightmute	(40) Lime Village	(44) Brevig Mission	

Table A-10. Flood Group 2 (alphabetical with ranking indicated).

(41) Akhiok	(32) Eyak	(40) Lime Village	(36) Rampart
(36) Aniak	(44) Gakona	(37) Manley Hot Springs	(44) Saint George
(44) Anvik	(30) Grayling	(31) Marshall	(41) Saint Mary's
(45) Barrow	(29) Gulkana	(44) Mekoryuk	(40) Scammon Bay
(44) Beaver	(36) Holy Cross	(44) New Koliganek	(42) Selawik
(44) Brevig Mission	(36) Hoonah	(44) New Stuyahok	(33) Shageluk
(35) Chalkyitsik	(46) Hooper Bay	(41) Newtok	(38) Stevens
(44) Chefornak	(34) Huslia	(35) Nightmute	(39) Tanacross
(46) Chignik Lagoon	(38) Kaltag	(38) Nikolai	(41) Toksook Bay
(35) Chistochina	(34) Kipnuk	(40) Noatak	(28) Togiak
(42) Copper Center	(44) Klawock	(35) Nuiqsut	(43) Tununak
(35) Crooked Creek	(36) Kobuk	(44) Pitka's Point	(40) Unalaska
(33) Diomede	(34) Kongiganak	(42) Point Hope	(36) Venetie
(44) Ekwok	(44) Koyuk	(37) Quinhagak	

Table A-11. Flood Group 3 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(47) Chenega Bay	(53) Tatitlek	(59) Ambler	(59) Port Lions
(48) Alatna	(54) Birch Creek	(59) Angoon	(59) Ruby
(48) Saint Michael	(54) Clarks Point	(59) Arctic	(59) Saint Paul
(49) Dillingham	(54) White Mountain	(59) Atka	(59) Nikiski
(49) Nondalton	(55) Chevak	(59) Chickaloon	(59) Sand Point
(49) Wales	(55) Haines	(59) Chignik Bay	(59) Saxman
(50) Kalskag (Lower)	(55) Nelson Lagoon	(59) Chitina	(59) Seldovia
(50) Kalskag (Upper)	(55) Pilot Point	(59) Chuathbaluk	(59) Shungnak
(50) Pilot Station	(55) Tazlina	(59) Eklutna	(59) South Naknek
(51) Port Heiden	(56) Anaktuvuk Pass	(59) Evansville	(59) Takotna
(51) Stony River	(56) Cantwell	(59) Hydaburg	(60) Noorvik
(51) Ugashik	(56) False Pass	(59) Kasaan	(61) Nanwalek
(52) Kake	(56) Goodnews Bay	(59) Kasigluk	(62) Igiugig
(52) Kwigillingok	(56) Nikolski	(59) King Cove	(63) Atqasuk
(52) Russian Mission	(56) Perryville	(59) Kokhanok	(63) Craig
(52) Tanana	(56) Tetlin	(59) Larsen Bay	(63) Eek
(52) Wainwright	(56) Twin Hills	(59) Levelock	(63) Egegik
(53) Atmautluak	(56) Tyonek	(59) Manokotak	(63) Iliamna
(53) Chignik Lake	(57) Kaktovik	(59) Mentasta	(63) Kiana
(53) Ninilchik	(57) Port Graham	(59) Mountain Village	(63) Minto
(53) Northway	(58) Platinum	(59) Naknek	(63) Newhalen
(53) Nunapitchuk	(58) Nunam Iqua	(59) Old Harbor	
(53) Oscarville	(59) Akutan	(59) Ouzinkie	
(53) Point Lay	(59) Aleknagik	(59) Pedro Bay	

Table A-12. Flood Group 3 (alphabetical with ranking indicated).

(59) Akutan
(48) Alatna
(59) Aleknagik
(59) Ambler
(56) Anaktuvuk Pass
(59) Angoon
(59) Arctic
(59) Atka
(53) Atmautluak
(63) Atqasuk
(54) Birch Creek
(56) Cantwell
(47) Chenega Bay
(55) Chevak
(59) Chickaloon
(59) Chignik Bay
(53) Chignik Lake
(55) Haines
(59) Chitina
(59) Chuathbaluk
(54) Clarks Point
(63) Craig
(49) Dillingham
(63) Eek
(63) Egegik
(59) Eklutna
(59) Evansville
(56) False Pass
(56) Goodnews Bay
(59) Hydaburg
(62) Igiugig
(63) Iliamna
(52) Kake
(57) Kaktovik
(50) Kalskag (Lower)
(50) Kalskag (Upper)
(59) Kasaan
(59) Kasigluk
(63) Kiana
(59) King Cove
(59) Kokhanok
(52) Kwigillingok
(59) Larsen Bay
(59) Levelock
(59) Manokotak
(59) Mentasta
(63) Minto
(59) Mountain Village
(59) Naknek
(61) Nanwalek
(55) Nelson Lagoon
(63) Newhalen
(56) Nikolski
(53) Ninilchik
(49) Nondalton
(60) Noorvik
(53) Northway
(58) Nunam Iqua
(53) Nunapitchuk
(59) Old Harbor
(53) Oscarville
(59) Ouzinkie
(59) Pedro Bay
(56) Perryville
(55) Pilot Point
(50) Pilot Station
(58) Platinum
(53) Point Lay
(57) Port Graham
(51) Port Heiden
(59) Port Lions
(59) Ruby
(52) Russian Mission
(48) Saint Michael
(59) Saint Paul Island
(59) Salamatoff
(59) Sand Point
(59) Saxman
(59) Seldovia
(59) Shungnak
(59) South Naknek
(51) Stony River
(59) Takotna
(52) Tanana
(53) Tatitlek
(55) Tazlina
(56) Tetlin
(56) Twin Hills
(56) Tyonek
(51) Ugashik
(52) Wainwright
(49) Wales
(54) White Mountain

Thawing Permafrost Rankings

Table A-13. Permafrost Group 1 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(1) Newtok
(2) Barrow
(2) Point Lay
(3) Tuntutuliak
(3) Kongiganak
(4) Saint Michael
(4) Savoonga
(4) Noatak
(4) Kaktovik
(4) Selawik
(4) Nunapitchuk
(4) Nightmute
(4) Kwinhagak
(4) Nuiqsut
(4) Buckland
(4) Sheldon's Point
(4) Wainwright
(4) Noorvik
(4) Atqasuk
(5) Huslia
(5) Chevak
(5) Eek
(5) Nunakauyarmiut
(5) Stebbins
(5) Kiana
(5) Shungnak
(6) Deering
(6) Alatna
(7) Chefornak
(7) Mekoryuk
(7) Brevig Mission
(8) Circle
(8) Atmautluak
(9) Nome Eskimo
(9) Kotzebue

Table A-14. Permafrost Group 1 (alphabetical with ranking indicated).

(6) Alatna
(8) Atmautluak
(4) Atqasuk
(2) Barrow
(7) Brevig Mission
(4) Buckland
(7) Chefornak
(5) Chevak
(8) Circle
(6) Deering
(5) Eek
(5) Huslia
(4) Kaktovik
(5) Kiana
(3) Kongiganak
(9) Kotzebue
(7) Mekoryuk
(1) Newtok
(4) Nightmute
(4) Noatak
(9) Nome
(4) Noorvik
(4) Nuiqsut
(4) Nunapitchuk
(2) Point Lay
(4) Quinhagak
(4) Saint Michael
(4) Savoonga
(4) Selawik
(4) Sheldon's Point
(5) Shungnak
(5) Stebbins
(5) Toksook Bay
(3) Tuntutuliak
(4) Wainwright

Table A-15. Permafrost Group 2 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(10) Gulkana
(10) Kipnuk
(10) Bethel
(10) Galena
(10) Allakaket
(10) Marshall
(10) Koyuk
(10) Holy Cross
(10) Anaktuvuk Pass
(11) Mountain Village
(12) Kwigillingok
(12) Kasigluk
(13) Golovin
(13) Tununak
(13) Fort Yukon
(13) Kalskag (Upper)
(13) Manley Hot Springs
(13) Teller
(13) Nulato
(13) Akiachak
(13) Kaltag
(13) Beaver
(13) Pilot Station
(14) Kwethluk
(15) South Naknek
(15) Gambell
(15) Saint Mary's
(15) Rampart
(15) Pitka's Point
(15) Arctic
(15) Takotna
(16) Lime Village
(16) Emmonak
(16) Hooper Bay
(16) Russian Mission
(17) Point Hope
(17) Evansville
(17) Kalskag (Lower)
(17) Hughes
(17) Shageluk
(17) Eagle
(17) Tuluksak
(17) Tanana
(17) New Stuyahok
(17) Stevens
(17) Kobuk
(17) Crooked Creek
(17) Tanacross
(18) Shishmaref
(18) Kotlik
(18) Alakanuk
(18) Oscarville
(18) Chitina
(18) Ruby

Table A-16. Permafrost Group 2 (alphabetical with ranking indicated).

(13) Akiachak	(15) Gambell	(14) Kwethluk	(16) Russian Mission
(18) Alakanuk	(13) Golovin	(12) Kwigillingok	(15) Saint Mary's
(10) Allakaket	(10) Gulkana	(16) Lime	(17) Shageluk
(10) Anaktuvuk Pass	(10) Holy Cross	(13) Manley Hot Springs	(18) Shishmaref
(15) Arctic Village	(16) Hooper Bay	(10) Marshall	(15) South Naknek
(13) Beaver	(17) Hughes	(11) Mountain Village	(17) Stevens
(10) Bethel	(17) Kalskag (Lower)	(17) New Stuyahok	(15) Takotna
(18) Chitina	(13) Kalskag (Upper)	(13) Nulato	(17) Tanacross
(17) Crooked Creek	(13) Kaltag	(18) Oscarville	(17) Tanana
(17) Eagle	(12) Kasigluk	(13) Pilot Station	(13) Teller
(16) Emmonak	(10) Kipnuk	(15) Pitka's Point	(17) Tuluksak
(17) Evansville	(17) Kobuk	(17) Point Hope	(13) Tununak
(13) Fort Yukon	(18) Kotlik	(15) Rampart	
(10) Galena	(10) Koyuk	(18) Ruby	

Table A-17. Permafrost Group 3 (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(19) Napaskiak	(22) Grayling	(23) Ouzinkie	(23) Hoonah
(20) Kivalina	(22) Chalkyitsik	(23) Chignik Lagoon	(23) Ekwok
(20) Shaktoolik	(22) Anvik	(23) Old Harbor	(23) Klawock
(20) Unalakleet	(22) Gakona	(23) Salamatoff	(23) Chenega Bay
(20) Elim	(22) Tazlina	(23) Saint Paul Island	(23) Nondalton
(21) Napakiak	(22) Cantwell	(23) Akhiok	(23) Stony River
(21) Naknek	(22) Goodnews Bay	(23) Chignik Bay	(23) Haines
(21) Scammon Bay	(22) Tetlin	(23) Togiak	(23) Perryville
(21) New Koliganek	(22) Ambler	(23) Yakutat	(23) Twin Hills
(21) Minto	(22) Eklutna	(23) Ninilchik	(23) Tyonek
(22) Dillingham	(22) Chuathbaluk	(23) Red Devil	(23) Akutan
(22) McGrath	(22) Mentasta	(23) Kake	(23) Angoon
(22) Venetie	(23) Port Heiden	(23) Tatitlek	(23) Atka
(22) Aniak	(23) Akiak	(23) Port Lions	(23) Kasaan
(22) Egegik	(23) Nelson Lagoon	(23) Unalaska	(23) Kokhanok
(22) Diomede	(23) Levelock	(23) Saint George	(23) Pedro Bay
(22) Nenana	(23) Pilot Point	(23) Nikolski	(23) Sand Point
(22) Wales	(23) Clarks Point	(23) Chickaloon	(23) Saxman
(22) Nikolai	(23) False Pass	(23) King Cove	(23) Seldovia
(22) Northway	(23) Aleknagik	(23) Ugashik	(23) Newhalen
(22) Koyukuk	(23) Nanwalek	(23) Chignik Lake	(23) Hydaburg
(22) Birch Creek	(23) Eyak	(23) Larsen Bay	(23) Craig
(22) White Mountain	(23) Igiugig	(23) Manokotak	
(22) Chistochina	(23) Iliamna	(23) Platinum	
(22) Copper Center	(23) Port Graham	(23) Sleetmute	

Table A-18. Permafrost Group 3 (alphabetical with ranking indicated).

(23) Akhiok
(23) Akiak
(23) Akutan
(23) Aleknagik
(22) Ambler
(23) Angoon
(22) Aniak
(22) Anvik
(23) Atka
(22) Birch Creek
(22) Cantwell
(22) Chalkyitsik
(23) Chenega Bay
(23) Chickaloon
(23) Chignik Bay
(23) Chignik Lagoon
(23) Chignik Lake
(22) Chistochina
(22) Chuathbaluk
(23) Clarks Point
(22) Copper Center
(23) Craig
(22) Dillingham
(22) Diomede
(22) Egegik
(22) Eklutna
(23) Ekwok
(20) Elim
(23) Eyak
(23) False Pass
(22) Gakona
(22) Goodnews Bay
(22) Grayling
(23) Haines
(23) Hoonah
(23) Hydaburg
(23) Igiugig
(23) Iliamna
(23) Kake
(23) Kasaan
(23) King Cove
(20) Kivalina
(23) Klawock
(23) Kokhanok
(22) Koyukuk
(23) Larsen Bay
(23) Levelock
(23) Manokotak
(22) McGrath
(22) Mentasta
(21) Minto
(21) Naknek
(23) Nanwalek
(21) Napakiak
(19) Napaskiak
(23) Nelson Lagoon
(22) Nenana
(21) New Koliganek
(23) Newhalen
(22) Nikolai
(23) Nikolski
(23) Ninilchik
(23) Nondalton
(22) Northway
(23) Old Harbor
(23) Ouzinkie
(23) Pedro Bay
(23) Perryville
(23) Pilot Point
(23) Platinum
(23) Port Graham
(23) Port Heiden
(23) Port Lions
(23) Red Devil
(23) Saint George
(23) Saint Paul
(23) Salamatoff
(23) Sand Point
(23) Saxman
(21) Scammon Bay
(23) Seldovia
(20) Shaktoolik
(23) Sleetmute
(23) Stony River
(23) Tatitlek
(22) Tazlina
(22) Tetlin
(23) Togiak
(23) Twin Hills
(23) Tyonek
(23) Ugashik
(20) Unalakleet
(23) Unalaska
(22) Venetie
(22) Wales
(22) White Mountain
(23) Yakutat

Combined Rankings

Table A-19. Communities sorted by combined score rankings (by ranking from highest to lowest). Communities with the same ranking indicates equal threat ratings.

(1) Shaktoolik
(2) Shishmaref
(3) Kivalina
(4) Golovin
(5) Napakiak
(6) Alakanuk
(7) Newtok
(8) Unalakleet
(9) Savoonga
(10) Kotlik
(11) Emmonak
(12) McGrath
(13) Fort Yukon
(14) Deering
(14) Eagle
(15) Hughes
(15) Huslia
(16) Galena
(17) Circle
(18) Saint Michael
(19) Bethel
(20) Tuluksak
(21) Allakaket
(22) Akiak
(23) Napaskiak
(24) Chefornak
(25) Noatak
(26) Tuntutuliak
(27) Nome
(28) Kwethluk
(29) Koyukuk
(30) Kotzebue
(30) Teller
(31) Buckland
(32) Gulkana
(33) Barrow
(34) Elim
(34) Lime Village
(35) Port Heiden
(36) Nenana
(37) Kongiganak
(38) Kipnuk
(38) Quinhagak
(39) Kwigillingok
(39) Stebbins
(40) Nightmute
(40) Venetie
(41) Chevak
(41) Gambell
(41) Tununak
(42) Dillingham
(42) Selawik
(43) Akiachak
(44) Nuiqsut
(45) Nulato
(46) Aniak
(46) Point Hope
(46) Shageluk
(47) Diomede
(48) Manley Hot Springs
(49) Kaktovik
(50) Hooper Bay
(51) Mekoryuk
(52) Marshall
(53) Eyak
(53) Kalskag (Lower)
(54) Evansville
(54) Kalskag (Upper)
(55) Brevig Mission
(56) Alatna
(57) Nikolai
(58) Nelson Lagoon
(58) Nunapitchuk
(58) Red Devil
(59) South Naknek
(59) Togiak
(60) Grayling
(61) Atmautluak
(61) Holy Cross
(61) Yakutat
(62) Sheldon's Point
(63) Wainwright
(64) Crooked Creek
(64) Kobuk
(64) Oscarville
(64) Rampart
(65) Wales
(66) Russian Mission
(66) Stevens
(67) Kaltag
(67) Tanana
(68) Levelock
(69) Pilot Point
(70) Chistochina
(70) Clarks Point
(71) Koyuk
(71) Saint Mary's
(71) Sleetmute
(71) Tanacross
(72) Chalkyitsik
(72) Point Lay
(73) New Stuyahok
(74) Naknek
(75) Beaver
(75) False Pass
(75) Northway
(76) Egegik
(76) Pitka's Point
(77) Scammon Bay
(78) Eek
(79) Aleknagik
(80) Akhiok
(81) Chignik Lagoon
(81) Copper Center
(81) Shungnak
(83) New Koliganek
(83) Pilot Station
(84) Anvik
(84) Gakona
(85) Anaktuvuk Pass
(86) Noorvik
(87) Port Graham
(88) Mountain Village
(89) Hoonah Indian
(90) Birch Creek
(90) Kasigluk
(90) White Mountain
(91) Ouzinkie
(92) Arctic
(92) Nanwalek
(92) Takotna
(93) Umkumiute
(94) Atqasuk
(94) Unalaska
(95) Chitina
(95) Ruby
(96) Kiana
(97) Old Harbor
(97) Salamatoff
(98) Igiugig
(98) Tazlina
(99) Cantwell
(99) Goodnews Bay
(99) Saint George
(99) Tetlin
(100) Saint Paul
(101) Ambler
(101) Chignik Bay
(101) Chuathbaluk
(101) Eklutna
(101) Ekwok
(101) Iliamna
(101) Klawock
(102) Ninilchik
(103) Kake
(104) Chenega Bay
(104) Tatitlek
(105) Nondalton
(105) Ugashik
(106) Chignik Lake
(106) Stony River
(107) Nikolski
(108) Port Lions
(109) Haines
(110) Chickaloon
(110) King Cove
(110) Perryville
(110) Twin Hills
(110) Tyonek
(111) Larsen Bay
(111) Manokotak
(111) Platinum
(112) Akutan
(112) Angoon
(112) Atka
(112) Kasaan
(112) Kokhanok
(112) Mentasta
(112) Pedro Bay
(112) Sand Point
(112) Saxman
(112) Seldovia
(113) Minto
(114) Hydaburg
(114) Newhalen
(115) Craig

Table A-20. Combined score rankings in alphabetical order.

(80) Akhiok
(43) Akiachak
(22) Akiak
(112) Akutan
(56) Alatna
(79) Aleknagik
(21) Allakaket
(6) Alakanuk
(101) Ambler
(85) Anaktuvuk Pass
(112) Angoon
(46) Aniak
(84) Anvik
(92) Arctic
(112) Atka
(61) Atmautluak
(94) Atqasuk
(33) Barrow
(75) Beaver
(19) Bethel
(90) Birch Creek
(55) Brevig Mission
(31) Buckland
(99) Cantwell
(72) Chalkyitsik
(24) Chefornak
(104) Chenega Bay
(41) Chevak
(110) Chickaloon
(101) Chignik Bay
(81) Chignik Lagoon
(106) Chignik Lake
(109) Haines
(70) Chistochina
(95) Chitina
(101) Chuathbaluk
(17) Circle
(70) Clarks Point
(81) Copper Center
(115) Craig
(64) Crooked Creek
(14) Deering
(42) Dillingham
(47) Diomede
(14) Eagle
(78) Eek
(76) Egegik
(101) Eklutna
(101) Ekwok
(34) Elim
(11) Emmonak
(54) Evansville
(53) Eyak
(75) False Pass
(13) Fort Yukon
(84) Gakona
(16) Galena
(41) Gambell
(4) Golovin
(99) Goodnews Bay
(60) Grayling
(32) Gulkana
(61) Holy Cross
(89) Hoonah Indian
(50) Hooper Bay
(15) Hughes
(15) Huslia
(114) Hydaburg
(98) Igiugig
(101) Iliamna
(103) Kake
(49) Kaktovik
(53) Kalskag (Lower)
(54) Kalskag (Upper)
(67) Kaltag
(112) Kasaan
(90) Kasigluk
(96) Kiana
(110) King Cove
(38) Kipnuk
(3) Kivalina
(101) Klawock
(64) Kobuk
(112) Kokhanok
(37) Kongiganak
(10) Kotlik
(30) Kotzebue
(71) Koyuk
(29) Koyukuk
(28) Kwethluk
(39) Kwigillingok
(38) Kwinhagak
(111) Larsen Bay
(68) Levelock
(34) Lime Village
(48) Manley Hot Springs
(111) Manokotak
(52) Marshall
(12) McGrath
(51) Mekoryuk
(112) Mentasta
(113) Minto
(88) Mountain Village
(74) Naknek
(92) Nanwalek
(5) Napakiak
(23) Napaskiak
(58) Nelson Lagoon
(36) Nenana
(83) New Koliganek
(73) New Stuyahok
(114) Newhalen
(7) Newtok
(40) Nightmute
(57) Nikolai
(107) Nikolski
(102) Ninilchik
(25) Noatak
(27) Nome
(105) Nondalton
(86) Noorvik
(75) Northway
(44) Nuiqsut
(45) Nulato
(58) Nunapitchuk
(97) Old Harbor
(64) Oscarville
(91) Ouzinkie
(112) Pedro Bay
(110) Perryville
(69) Pilot Point
(83) Pilot Station
(76) Pitka's Point
(111) Platinum
(46) Point Hope
(72) Point Lay
(87) Port Graham
(35) Port Heiden
(108) Port Lions
(64) Rampart
(58) Red Devil
(95) Ruby
(66) Russian Mission
(99) Saint George Island
(71) Saint Mary's
(18) Saint Michael
(100) Saint Paul Island
(97) Salamatoff
(112) Sand Point
(9) Savoonga
(112) Saxman
(77) Scammon Bay
(42) Selawik
(112) Seldovia
(46) Shageluk
(1) Shaktoolik
(62) Sheldon's Point
(2) Shishmaref
(81) Shungnak
(71) Sleetmute
(59) South Naknek
(39) Stebbins
(66) Stevens
(106) Stony River
(92) Takotna
(71) Tanacross
(67) Tanana
(104) Tatitlek
(98) Tazlina
(30) Teller
(99) Tetlin
(59) Togiak
(20) Tuluksak
(26) Tuntutuliak
(41) Tununak
(110) Twin Hills
(110) Tyonek
(105) Ugashik
(8) Unalakleet
(94) Unalaska
(40) Venetie
(63) Wainwright
(65) Wales
(90) White Mountain
(61) Yakutat

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Appendix B – Prototype Scope of Work: Rural Alaska Coastal Erosion and Storm Surge Flood Assessment

PROTOTYPE SCOPE OF WORK[1]
RURAL ALASKA COASTAL EROSION AND STORM SURGE FLOOD ASSESSMENT

Prepared by
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Village Infrastructure Protection Program Manager
Denali Commission

September 2019

Background

Many communities throughout rural Alaska are experiencing escalating threats to their lands, infrastructure, and personal property due to the increasing risk of coastal flooding events. Impacts consist of water damage to homes, snow machines, ATV's and public facilities, damage to transportation systems, contamination of water supplies, dispersion of wastewater and solid waste throughout the community and inaccessible or lost land resources. There are multiple factors influencing flood risk including severity and frequency of storms, relative sea level rise and reduced sea ice during fall and winter storm seasons needed to dissipate storm energy. Typically, there is insufficient data available to community decision makers to fully understand community vulnerability to flood related life-safety risks and damage to critical infrastructure. Both site-specific analysis of historical flood magnitude and frequency as well as modeling of future conditions are necessary for understanding flood risk and to inform long-term community decision making regarding flood mitigation, managed retreat, and/or relocation.

The goal of this assessment is to provide essential site-specific information needed to precisely quantify flood threats to community security and to inform near-term and long-term decision making regarding the development of flood mitigation measures. Specifically, this assessment has the following objectives:

- Identify and analyze historical flood and storm data.
- Collect additional baseline data required for flood modeling.
- Forecast relative sea level rise (based on existing research).
- Develop and calibrate a nearshore hydrodynamic model of storm surge, waves, and wave run-up at the specific community location in order to forecast future water levels and sediment transport.
- Produce predictive flood scenarios maps layered on a community elevation model.
- Evaluate effectiveness and feasibility of structural measures to mitigate flood risk based on modeling. Consider shoreline and bank stabilization, flood resistant building techniques and renovations, and establishment of first floor build elevations.
- Determine long-term viability of the community site (75+ years) based on model projections and the potential to effectively mitigate risks.

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[1] This is a generic scope of work intended as a reference document that can be used to guide the development of a detailed community specific scope of work.

- Evaluate the relative efficacy of non-structural mitigation measures (e.g. managed retreat away from flood threat) in comparison to structural measures.
- Develop recommendations for both near-term and long-term mitigation measures.

Scope of Work

The following tasks will be implemented in order to accomplish the objectives of this project. Professional coastal engineers, scientists, and community planners shall be engaged to complete Tasks 2 to 8 in direct consultation with the community.

Task 1: Project Management (Provided by Community)

A. Develop and implement a solicitation process to contract for the professional services required to carry out the project. In the event that the community already has access to professional engineering services procured in accordance with funding agency requirements, then this task will not be required.

B. Conduct all general project management activities including award management, contract management, scheduling, meeting coordination, and other project activities.

Task 2: Preliminary Assessment

- Conduct a teleconference with community leadership to identify key community contacts and concerns; gather local knowledge about flooding; identify available technical reports and data; and obtain input on the assessment methodology.

- Identify and review existing information including but not limited to the following:
  - Historical imagery and digital elevation or surface models
  - Bathymetric and topographic data sets for the study area
  - Tidal datums
  - Sea ice observations
  - Wind and storm data
  - Wave information: National Buoy Data Center (NBDC) and U.S. Army Corps of Engineers (USACE) Wave Information Studies (WIS)
  - Geotechnical reports from infrastructure projects (school, sanitation facilities, clinic, airport, etc.)
  - Summarize historical and projected climate data for the community using Scenarios Network for Alaska/Arctic Planning (SNAP) resources (https://www.snap.uaf.edu/tools-data/data-downloads)
  - Flood information from local hazard mitigation plan and other hazard analysis reports
  - USACE Floodplain Management resources
  - Alaska Water Level Watch (https://www.facebook.com/AlaskaWaterLevelWatch/ and https://aoos.org/alaska-water-level-watch/)
  - Denali Commission threat assessment database
  - Other relevant technical studies and data sources relating to historical shoreline change, wind, waves, tides, storm surge, sea ice, and sea level rise

- Interpret historical flood elevations from available collated flood data via analysis of photos, ortho-imagery and elevation data to identify co-registered data points of flood height and/or flood extent.

- Create a preliminary map of historical floods on a community elevation model. Identify ground elevations that would result in minor, moderate, and major flooding (in accordance with NOAA National Weather Service definitions) at various storm stages.

- Conduct a geotechnical desktop review of available climate projections and subsurface data for the purpose of estimating ground settlement associated with permafrost thaw.

- Identify additional baseline data required to complete a hydro-dynamic model.

- Submit storm photographs to Alaska DGGS for upload to the photo database at http://maps.dggs.alaska.gov/photodb/; add storm elevations to AOOS Alaska Water Level Watch portal.

Task 3: Site Visit and Field Investigation(s)

The consultant's team (engineers, scientists, surveyors) shall travel to the community to conduct field assessment(s) as described below. The field assessment(s) will consist of the following:

A. Kick-off meeting with community stakeholders (including but not limited to the Tribe, City, and Corporation) to present the preliminary flood maps; discuss the project; and discuss community observations regarding current and future flood risk.

B. Complete interviews with community members on flood history in and around the community.

C. Conduct a visual inspection of coastal topography to confirm and/or update the limits of historical storm events.

D. Gather additional baseline data needed to conduct flood modeling exercise:
   - Aerial Survey: Gather new or supplemental aerial photography and/or lidar data required to develop both a digital elevation or surface model of the coastline and built community and co-registered ortho-imagery. Horizontal and vertical accuracy of point cloud data on bare earth surfaces will average 0.1 feet.
   - Land Survey: A land survey shall be completed to coordinate horizontal and vertical control of existing data sets, to develop coastal elevation profiles, to measure finished floor elevations of critical infrastructure (school, clinic, power plant, fuel tank farm, water treatment plant, store, city and tribal offices, evacuations centers, etc.) and occupied homes in the community. Existing survey data shall be utilized to the greatest extent possible to eliminate redundant data collection.
   - Bathymetric Survey: Design and conduct a survey to gather near shore and off shore bathymetry sufficient to conduct storm surge and wave runup analysis. Conduct bathymetry utilizing modern multi-beam, single-beam and/or side scan echosounders. If utilizing a single beam echosounder in a soft bottom environment, it is recommended to utilize a dual frequency system to identify soft surface layers and the harder bottom layer. For communities located on barrier island and spit formations, survey coverage shall include the lagoon side of the community and tidal inlets. Horizontal and vertical accuracy of bathymetry data points will average 0.3 feet.
   - Water Level Data: Collect sufficient water level data to establish a local tidal datum based on simultaneous comparison with an existing tide station. Estimate impact on modeling accuracy due to the distance from an authoritative datum.
   - Current and Sediment Data: Collect sufficient current and sediment data required to model sediment transport and coastal erosion processes. Acoustic Doppler Current Profilers shall be deployed to obtain current information at strategic locations. Sediment grab samples shall be

taken along the ocean beach, lagoon beach (if applicable), at accreting portions of the beach, and other specific sites of interest. Grab samples shall be lab tested to determine classification and particle size.

- Note: Consideration of alternate emerging technologies that may reduce the cost of data collection are encouraged (e.g. topo-bathy lidar).

E. Photograph all infrastructure constructed along the shoreline in the active beach zone. Conduct a structural assessment of identified infrastructure to determine if they can be relocated.

Task 4: Hydrodynamic Flood Modeling

This task includes the development of a 3-dimensional coastal hydraulic model after completion of field investigations. The following elements will be included in the modeling exercise.

A. Delineate modeling boundaries and assumptions.

B. Develop model to simulate near shore wave action including wave set-up and run-up in the waters surrounding the community, incorporating collated topographic, bathymetric, storm, wind, and water level data.

C. Calibrate the model via hindcast simulations of historical flood events documented during field reconnaissance.

D. Complete predictive flood simulations (25, 50, 100-year horizons) based on adopted projections of sea level rise, storm, and ice conditions. Develop return interval flood scenarios mapped on community elevation model.

Task 5: Sediment Transport Modeling and Erosion Analysis

This task includes sediment transport modeling to predict coastal erosion and aid in the development of mitigation measures. The following elements will be included in the modeling and analysis.

A. Develop model to simulate near shore sediment transport for past high-water high-wave events and for storm magnitudes predicted in the future, incorporating sediment characteristics based on samples collected during site investigation activities.

B. Quantify erosion rates and formulate predictions of future changes that will impact near term infrastructure mortality (5-10 years) and the long-term stability (75+ years) of the community.

Task 6: Engineering Analysis

This task includes performing the following engineering analysis upon completion of flood and erosion modeling.

A. Establish hydraulic and hydrodynamic forcing criteria required for engineering design of mitigation measures.

B. Develop a list of recommended structural solutions to mitigate damage from flooding and coastal erosion.

C. Compare the feasibility and cost effectiveness of structural solutions with a managed retreat response.

D. Evaluate whether the community can stay and defend at its current site (including managed retreat), or whether complete relocation will be required over the next 75-year horizon. The determination shall be primarily based on livability of the site based on flood modeling projections and the ability to mitigate flood risk in both a feasible and socially acceptable manner.

E. Develop a prioritized list of conceptual-level structural mitigation measures based on community input. For each of the top three priorities, develop a detailed project scope, schedule, and budget sufficient to support an application for grant funding.

F. Develop a list of recommended non-structural best practices that can be immediately implemented by the community to mitigate flood impacts.

G. Cross reference recommended mitigation measures with the community's existing Local Hazard Mitigation Plan (LHMP) in order to develop a list of recommended updates to the LHMP.

Task 7: Reporting

Develop a final report documenting the entire modeling and analysis. The report shall be supported by maps, images, figures, conceptual drawings, and graphics of the model runs in order to maximize the usage of the report as a tool for community planning and decision-making. Upon completion of the report, the consultant will schedule a final meeting in the community to present the results.

The final report shall incorporate the following sections:

A. Introduction and Background: Describe the purpose and scope of the flood assessment.

B. Baseline data: Describe baseline data needs, available information, and supplemental data that was collected as part of the study.

C. Investigation Methodology: Describe the methodology used to develop the flood assessment. Include a description of the desktop evaluation, community meetings and interviews, and field investigations, and modeling.

D. Existing Conditions: Present the results of the study related to current conditions and include a discussion of the following topics: 1) historical flooding; 2) identification of the specific infrastructure found to be imminently threatened; and 3) a summary of the structural assessments of threatened buildings.

E. Projected Future Impacts: Summarize expected flood and erosion impacts based on modeling projections. Delineate community infrastructure that may be at risk based on predicted return interval flooding. Utilize both maps and tables to present the results. (Include poster-sized maps for community presentations.)

F. Best Practices and Solutions: Provide a narrative description of the non-structural practices that can be locally implemented to mitigate flood risk and impacts. Define recommended structural solutions and present the scope, schedule, and estimated cost for the identified priority community projects.

G. Next Steps and Long-term Recommendations: Discuss additional data collection recommendations and provide concluding recommendations that may be used by the community to develop long-term responses to flood hazards.

H. Appendices (Documentation): The report will include appendices as required to capture project records including trip reports, photographs, relevant survey and field notes. The section will include a bibliography of all previous plans, studies, designs, geotechnical reports, and other technical documents identified and used in the evaluation.

Task 8: Records Management

A. All data collected and/or generated by this effort will be archived for public access. Data will be provided both to Alaska Division of Geological and Geophysical Surveys and will be added to the Denali Commission Statewide Threat Assessment geodatabase in ArcGIS.

Project Schedule

\Ideally, this assessment can be completed in 12 -18 months, depending on the magnitude of baseline data collection that is required, availability of funding and the date of the Notice to Proceed (NTP). Under the ideal scenario, the solicitation would be completed in January and February, the preliminary assessment from March to May, field work from June to September, and modeling, analysis and reporting from October to December. The field investigation must take place during summer months free from snow and ice. The schedule and key milestones will be adjusted based on the NTP date to accommodate the field investigation.

A general schedule is presented below.

Task 1A (project management by the community): Months 1-12
Task 1B (engineering consultant solicitation): Months 1-2
Task 2 (preliminary assessment): Months 1-5
Task 3 (site visit): Month 6-9
Tasks 4 - 6 (modeling, analysis, and reporting): Months 9-10
Task 7 (reporting): Months 11-12

Appendix C – Prototype Scope of Work: Rural Alaska Riverine Erosion Assessment

PROTOTYPE SCOPE OF WORK[2]
RURAL ALASKA RIVERINE EROSION ASSESSMENT

Prepared by
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September 2019

Background

In 2009, the U.S. Army Corps of Engineers (USACE) completed the *Alaska Baseline Erosion Assessment* (BEA). The report found that most Alaskan communities are facing some level of infrastructure threat due to erosion. Drivers of erosion are variable and include naturally occurring changes in river channels, diminishing winter ice, storm surge, relative sea level rise, flooding, and human activities which impact shoreline ecosystems. The impacts of erosion on Alaskan communities range from minor damage to landscapes, to damage to transportation and utility infrastructure, to loss of individual or multiple structures, up to and including wholescale threats to community viability.

In the BEA, USACE identified 27 Priority Action communities, concluding that additional site-specific data and information was required for these communities in order to develop informed responses to the identified threats. Since 2009, little additional progress has been made to address the information gap identified by USACE. Too often, community decision-makers lack the scientific data and assessments required to fully forecast the magnitude and timing of erosion threats.

The goal of this assessment is to provide essential information needed to precisely quantify erosion threats to community security and to inform near-term and long-term decision making and mitigation measure development. Specifically, this assessment has the following objectives:

- Delineate near term (5-10 years) threats to community infrastructure based on an assessment of historical linear erosion rates
- Identify primary factors driving active erosion (geomorphic and anthropogenic)
- Establish long-term erosion projections based on hydrologic and hydraulic river modeling
- Evaluate effectiveness and feasibility of structural mitigation measures (barriers and bank stabilization) based on design criteria established through river modeling
- Evaluate the relative efficacy of non-structural mitigation measures (e.g. managed retreat away from erosion threat) in comparison to structural measures
- Determine long term viability of the current community site based on model projections

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[2] This is a generic scope of work intended as a reference document that can be used to guide the development of a detailed community specific scope of work.

- Develop recommendations for both near-term and long-term mitigation measures
- Build local capacity to address harmful environmental trends

Scope of Work

The following tasks will be implemented in order to accomplish the objectives of this project. Professional engineers, geologists, and community planners shall be engaged to complete Tasks 2 - 6 in direct consultation with the community.

Task 1: Project Management (Provided by Community)

A. Develop and implement a solicitation process to contract for the professional services required to carry out the project. In the event that the community already has access to professional engineering services procured in accordance with the requirements of 2 CFR 200, then this task will not be required.

B. Conduct all general project management activities including award management, contract management, scheduling, meeting coordination, and other project activities.

Task 2: Preliminary Assessment

A. Conduct a teleconference with community leadership to identify key community contacts and concerns; gather local knowledge about erosion, identify available technical reports and data, and obtain input on the assessment methodology.

B. Complete interviews with key community stakeholders regarding the history of erosion in and around the community.

C. Identify and review existing information including but not limited to the following:
   - Historical aerial imagery datasets.
   - Bathymetric and topographic data sets for the study area.
   - Geotechnical reports for major infrastructure development projects (school, sanitation facilities, clinic, airport, etc.).
   - The current hazard mitigation plan and other reports related to environmental hazard analysis.
   - Denali Commission threat assessment database.
   - Other relevant technical studies and data sources relating to historical shoreline change, wind, waves, tides, storm surge, sea level rise, and river hydrology.

D. Collaborate with relevant agencies and entities to ensure that all available information is considered (Alaska DGGS, Alaska DOT&PF, NOAA, USACE, NWS, VSW and ANTHC).

E. Summarize historical climate data and projected climate scenarios for the community using Scenarios Network for Alaska/Arctic Planning (SNAP).

F. Summarize projected changes to frozen ground and resulting implications for long-term erosion rates using public resources from SNAP, CRREL and UAF.

G. Create a preliminary decadal erosion projection map for the developed community and any surrounding areas proposed for future development. Overlay linear erosion projections on a map of community infrastructure to estimate the timing of the erosion impact on specific community

infrastructure. Convert annual rate of change to anticipated time of impact. Use site maps and charts to summarize and communicate the findings.

Task 3: Site Visit / Field Investigation

A team minimally consisting of a structural engineer, a hydrologist or geologist, and surveyors shall travel to the community to conduct a field assessment. It is expected that the assessment will require a minimum of 3 full days in the field. The field assessment will consist of the following:

A. Kick-off meeting with community stakeholders (including but not limited to the Tribe, City, and Corporation) to present the preliminary erosion projections; discuss the project; and discuss community observations regarding current and future erosion threats.

B. Visually survey the reach of river above, below, and through the community.

C. Conduct a visual inspection of site topography and terrain features to confirm and/or update the preliminary erosion projections. Employ additional field investigation techniques, including aerial drone photography, to improve the erosion projections and further document the current shoreline.

D. Complete topographic, bathymetric, and river flow surveys to gather baseline data necessary to conduct hydrologic and hydraulic modeling of the river system.
   - Topographic surveys will be conducted using an Unmanned Aerial Vehicle (UAV) with an on-board survey-grade global positioning system (GPS) technology. Horizontal and vertical accuracy of point cloud data on bare earth surfaces will average 0.1 feet.
   - Bathymetric surveys will be conducted utilizing dual frequency eco-sounder technology to identify soft surface layers and the hard bottom. Horizontal and vertical accuracy of bathymetry data points will average 0.1 feet.
   - Topographic and bathymetric data will be merged and complemented with available LiDAR data to extend the range of upstream and downstream river analysis.

E. Observe and/or investigate daily practices in the community that may contribute to erosion. These practices may include but are not limited to pedestrian and vehicular travel ways, river access, and boat landing and parking.

F. Photograph all infrastructure along the shoreline expected to be impacted within ten years based on the preliminary results and knowledge from the community.

G. Conduct a structural engineering assessment of all infrastructure expected to be impacted within five years in order to determine if structures can be relocated to a new site. If relocation is feasible, provide recommendations on relocation methodology.

H. Coordinate with community stakeholders to identify and evaluate least two new sites within the community or on property immediately adjacent to the exiting community, to which imminently threatened infrastructure may be relocated. Site analysis will include the following considerations:
   - Determination of minimum acreage required based on a review of threatened structures
   - Surface and subsurface characterization with respect to constructability
   - Evaluation of flood, erosion, and permafrost degradation risk
   - Delineation of site control issues
   - Site access
   - Utility service potential

- Environmental permitting
- Development costs
- Cultural considerations and/or other factors identified by the community

Task 4: Hydrologic and Hydraulic Modeling and Analysis

Upon completion of the field study, the following tasks will be completed prior to proceeding to the final report.

A. Complete a hydrologic analysis using USGS regression equations for Alaska to estimate river flows.

B. Develop a finite element hydro-dynamic model (RiverFlow2D or equivalent) to analyze river hydraulics. Utilize the model to estimate natural erosion and deposition processes along the river.
   - Consider the intersection of other threats (flooding, inundation, permafrost degradation, wave energy) with historical and projected erosion patterns. The overlay of historical erosion rates, geomorphology, and model-derived data will be used to interpret hot spots and areas of concern under expected future climate conditions.
   - Model future shoreline change across the community to predict infrastructure mortality.

C. Develop a list of recommended structural solutions to mitigate damage from erosion. Utilize the hydraulic model to analyze in-place mitigation measures.

D. Compare the efficacy of structural solutions with a managed retreat response.

E. Make a determination whether the community can stay and defend at its current site (including managed retreat), or whether complete relocation will be required. The determination shall be primarily based on viability of the site based on modeled erosion projections and the ability to mitigate erosion risk in both a feasible and socially acceptable manner.

F. Develop a prioritized list of mitigation measures based on community input. For each of the top three priorities, develop a detailed project scope, schedule, and budget sufficient to support an application for grant funding.

G. Develop a list of recommended non-structural best practices that can be immediately implemented by the community to mitigate erosion impacts.

Task 5: Reporting

Develop a final report documenting the entire evaluation. The report shall be supported by maps, images, figures, conceptual drawings, etc. to maximize the usage of the report as a tool for community planning and decision-making. Upon completion of the report, the consultant will schedule a final meeting in the community to present the results.

The final report shall incorporate the following sections:

A. Introduction and Background: Describe the purpose and scope of the vulnerability assessment.

B. Investigation Methodology: Describe the methodology used to develop the erosion assessment. Include a description of the desktop evaluation, community meetings and interviews, and field investigations, and modeling.

C. Existing Conditions: Present the results of the study related to current conditions and include a discussion of the following topics: 1) historical erosion rates and map; 2) summary of the structural assessments; 3) identification of the specific infrastructure found to be imminently threatened.

D. Projected Future Impacts: Summarize expected erosion impacts based on modeling projections. Delineate community infrastructure that may be at risk over the next 50 years due to projected erosion rates. Utilize both maps and tables to present the results.

E. Best Practices and Solutions: Provide a narrative description of the non-structural practices that can be locally implemented to limit and/or slow destructive permafrost degradation. Define recommended structural solutions and present the scope, schedule, and estimated cost for the identified priority community projects.

F. Next Steps and Long-term Recommendations: Discuss additional data collection recommendations and provide concluding recommendations that may be used by the community to develop long-term responses to environmental hazards.

G. Appendices (Documentation): The report will include appendices as required to capture project records including trip reports, photographs, relevant survey and field notes. The section will include a bibliography of all previous plans, studies, designs, geotechnical reports, and other technical documents identified and used in the evaluation.

Task 6: Records Management

B. All data collected and/or generated by this effort will be archived for public access. Data will be provided both to Alaska Division of Geological and Geophysical Surveys and will be added to the Denali Commission Statewide Threat Assessment geodatabase in ArcGIS.

Project Schedule

Ideally, this assessment can be completed in approximately 12 months, depending on the availability of funding and the date of the Notice to Proceed (NTP). Under the ideal scenario, the solicitation would be completed in January and February, the desktop assessment March to May, field work from June to September, and final reporting from October to December. The field investigation must take place during summer months free from snow and ice. The schedule and key milestones will be adjusted based on the NTP date to accommodate the field investigation.

A general schedule is presented below.

Task 1A (project management by the community): Months 1-12
Task 1B (engineering consultant solicitation): Months 1-2
Task 2 (desktop assessment): Months 1-5
Task 3 (site visit): Month 6-9
Task 4 (analysis and reporting): Months 9-10
Task 5 (reporting): Months 11-12
Task 6 (records management): Months 11-12

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Appendix D – Prototype Scope of Work: Rural Alaska Permafrost Vulnerability Assessment

PROTOTYPE SCOPE OF WORK[3]
RURAL ALASKA PERMAFROST VULNERABILITY ASSESSMENT

Prepared by
Donald Antrobus, PE
CAPT U.S. Public Health Service
Village Infrastructure Protection Program Manager
Denali Commission

September 2019

Background

Many communities throughout Alaska are experiencing significant impacts to infrastructure due to the thawing of permafrost. Impacts include failing structural foundations, damage to water and wastewater facilities, leaning storage tanks, and impassable roads. There are multiple factors driving changes to permafrost conditions including thermal impacts from heated infrastructure; human activities such as vehicular and pedestrian travel across delicate terrain; clearing and stockpiling of snow; warming climate and other natural phenomena such as flooding and erosion. Typically, there is insufficient data available to community decision makers that is needed both to understand community-wide vulnerability of infrastructure to permafrost thaw and to inform the development of long-term responses to these threats.

The goal of this assessment is to provide essential site-specific information needed to precisely quantify threats to community security from permafrost thaw and to inform near-term and long-term decision making regarding the development of effective mitigation measures. Specifically, this assessment has the following objectives:

- Characterize existing permafrost conditions throughout the community
- Define the primary factors driving changes to permafrost
- Identify current permafrost thaw impacts on infrastructure
- Project the potential magnitude of future impacts on infrastructure
- Define structural and behavioral measures to mitigate short-term impacts
- Develop long-term strategies to mitigate threats from permafrost thaw

Scope of Work

The following tasks will be implemented in order to accomplish the objectives of this project. Professional structural and geotechnical engineers and community planners shall be engaged to complete tasks 2-6 in direct consultation with the community.

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[3] This is a generic scope of work intended as a reference document that can be used to guide the development of a detailed community specific scope of work.

Task 1: Project Management (Provided by Community)

A. Develop and implement a solicitation process to contract for the professional services required to carry out the project. In the event that the community already has access to professional engineering services procured in accordance with funding agency requirements, then this task will not be required.

B. Conduct all general project management activities including award management, contract management, scheduling, meeting coordination, and other project activities.

Task 2: Desktop Assessment

A. Conduct a teleconference with community leadership to identify key community concerns; gather local knowledge about permafrost conditions, identify available technical reports and data, and obtain input on study methodology.

B. Complete interviews with key community contacts regarding the history of erosion and permafrost thaw in and around the community.

C. Identify and review existing information including but not limited to the following:

- Historical imagery, digital elevation or surface models, and terrain maps
- Current Local Hazard Mitigation Plan (LHMP) and other environmental hazard resources
- Geotechnical reports completed for major infrastructure development projects (school, sanitation facilities, clinic, airport, etc.)
- USACE Floodplain Management resources
- Alaska Water Level Watch (https://www.facebook.com/AlaskaWaterLevelWatch/ and https://aoos.org/alaska-water-level-watch/)
- Denali Commission threat assessment database
- Other relevant technical studies and data sources relating to historical shoreline change, wind, waves, tides, storm surge, sea ice, and sea level rise
- Collaborate with relevant State and Federal agencies (Alaska DGGS, UAF, ANTHC, VSW, NRCS, DOT&PF, NOAA, and NWS) to ensure that all available information is considered

D. Summarize historical and projected climate data for the community using Scenarios Network for Alaska/Arctic Planning (SNAP) resources.

E. Complete a preliminary permafrost characterization for the developed community and immediate surrounding areas identified or proposed for future development. Use site maps and charts to summarize and document the findings. To the extent possible based on existing data, the characterization shall capture general surface and subsurface conditions, soil classifications, depth of organics and depth to permafrost or of the active layer, ice and/or water content, occurrence of groundwater, potential occurrence of massive ice, and permafrost temperature. It is understood that the preliminary map may have significant data gaps.

F. Develop a plan for additional geotechnical or geophysical testing that may be required to supplement the preliminary permafrost characterization, with an emphasis on testing that is essential for determining geographical extent and ice content of permafrost in the community.

Task 3: Site Visit and Field Inspection

A team minimally consisting of a structural and geotechnical engineer shall travel to the community to conduct a field inspection. It is expected that the inspection will require a minimum of 3 full days in the field. The field inspection will consist of both structural and geotechnical assessments as follows:

A. Conduct a kick-off meeting with community stakeholders (including but not limited to the Tribe, City, and Corporation) to present the preliminary site characterization; discuss the project; and confirm community observations regarding current and future threats.

B. Visually inspect and photograph all public infrastructure to document impacts from melting permafrost, including roads, public buildings, sanitation facilities, bulk fuel tank farms, power plants, and other facilities identified by the community to be of concern. Include a minimum of 8 representative residential structures in the inspection.

C. Visually inspect and evaluate community drainage systems including ditches, culverts, and natural waterways.

D. Conduct a physical assessment of buildings including identification of foundation types, foundation cooling systems (e.g. active/passive freezing systems), environmental impacts (e.g. flowing water, ponding, snow drifting), and documentation of observed damage (e.g. detached/cracked foundations, uneven floors, cracked drywall, misaligned doors/windows, differential road or berm settlement, leaning tanks, separating utilidors, deformed/non-functioning culverts, etc.).

E. During the visual inspections, simultaneously document any observed impacts or imminent threats (expected impact in next 5 years) from flooding and erosion. For imminently threatened infrastructure, whether from permafrost thaw, flooding, or erosion, complete a preliminary structural assessment to determine whether the building is competent and able to be moved.

F. Conduct a visual inspection of site topography and terrain features to confirm and advance the preliminary permafrost characterization.

G. Conduct additional field investigation defined in task 2 in order to improve preliminary site permafrost characterization including aerial drone photography, and rod probing to determine depth to permafrost. If it is determined to be beneficial by the consultant and the community, use locally available equipment to pot hole shallow test pits to gain a better understanding of subsurface conditions in areas for which geotechnical information was not available during the desktop study.

H. Coordinate with community stakeholder to identify new sites within the existing community or on property immediately adjacent to the exiting community to which threatened infrastructure may be relocated. Include these sites in the inspection described above. Using similar techniques, develop an initial evaluation of the efficacy of the sites for new construction.

I. Observe and/or investigate daily practices which may have a negative impact on permafrost. These practices may include but are not limited to pedestrian and vehicular travel ways, river access, boat landing and parking, snow plowing and stockpiling, and greywater discharge.

Task 4: Analysis

Upon completion of the field inspection, the following tasks will be completed prior to producing the final report.

A. Update the preliminary permafrost characterization based on field observations and additional data collection.

B. Utilizing existing publicly available climate data, model future behavior of permafrost across the community. Use modeling results to predict the magnitude of future impacts to infrastructure due to permafrost thaw.

C. Develop a list of recommended non-structural best practices that can be implemented by the community to mitigate impacts from permafrost thaw.

D. Develop a list of recommended structural solutions for specific infrastructure to mitigate damage due to permafrost thaw (drainage, active cooling, leveling, elevating, etc.). Prioritize the list based on community input. For each of the top three priorities, develop a detailed project scope, schedule, budget, and implementation plan sufficient to support an application for grant funding.

E. Develop a plan for permafrost monitoring that can be locally implemented in order to continually track permafrost change over the next several decades. The monitoring plan shall be based on the techniques established by the Circumpolar Active Layer Monitoring (CALM) program, adapted for community specific conditions and resources.

F. Develop a list of best practices and recommendations to guide future community growth.

G. Cross reference recommended mitigation measures with the community's existing Local Hazard Mitigation Plan (LHMP) in order to develop a list of recommended updates to the plan.

Task 5: Final Reporting

Develop a final report documenting the entire evaluation. The report shall be supported by maps, images, figures, conceptual drawings, etc. to maximize the usage of the report as a tool for community planning and decision making. Upon completion of the report, the consultant will schedule a final meeting in the community to present the results.

The final report shall incorporate the following sections.

A. Introduction and Background: Describe the purpose and scope of the vulnerability assessment.

B. Baseline data: Describe available information, baseline data needs, and supplemental data that was collected as part of the study.

C. Investigation Methodology: Describe the methodology used to develop the permafrost assessment. Include a description of the desktop evaluation, community meetings and interviews, and field investigations.

D. Existing Conditions: Present the results of the study related to current conditions and include a discussion of the following topics: 1) permafrost characterization for the community site; 2) summary of the structural assessments; and 3) delineation of the specific infrastructure elements found to be immediately threatened.

E. Projected Future Impacts: Summarize the results of permafrost modeling based on future climate projections, considering both rising temperatures and increased precipitation. Delineate community infrastructure that may be at risk over the next 50 years due to projected permafrost thaw.

F. Best Practices and Solutions: Provide a narrative description of the non-structural practices that can be locally implemented to limit and/or slow destructive permafrost thaw. Define recommended structural solutions and report on the identified priority community projects. Delineate any recommendations for updates to the LHMP.

G. Next Steps and Long-term Recommendations: Discuss additional data collection recommendations and provide concluding recommendations that may be used by the community to develop long-term responses to environmental hazards.

H. Appendices (Documentation): The report will include appendices as required to capture project records including trip reports, photographs, relevant survey and field notes. The section will include a bibliography of all previous plans, studies, designs, geotechnical reports, and other technical documents identified and used in the evaluation.

Task 6: Records Management

A. All data collected and/or generated by this effort will be archived for public access. Data will be provided both to Alaska Division of Geological and Geophysical Surveys and will be added to the Denali Commission Statewide Threat Assessment geodatabase in ArcGIS.

Project Schedule

Ideally, this assessment can be completed in 12 -18 months, depending on the magnitude of baseline data collection that is required, availability of funding and the date of the Notice to Proceed (NTP). Under the ideal scenario, the solicitation would be completed in January and February, the preliminary assessment from March to May, field work from June to September, and modeling, analysis and reporting from October to December. This assumes that field investigations can be conducted during summer months that are free from snow and ice. If additional geotechnical testing must be conducted during the winter, then the schedule will be extended. The schedule and key milestones will be adjusted based on the date of the NTP and in order to accommodate field investigations.

A general schedule is presented below.

Task 1A (project management by the community): Months 1-12
Task 1B (engineering consultant solicitation): Months 1-2
Task 2 (preliminary assessment): Months 1-5
Task 3 (site visit and field inspection): Month 6-9
Tasks 4 - 5 (analysis and reporting): Months 9-10
Task 6 (reporting): Months 11-12

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Project Memorandum

To:	**Perkins Coie**	**Doc. No.:**	
Attention:	**Eric Fjelstad**	**cc:**	**Ron Rimelman** **Enric Fernandez**
From:	**Hamish Weatherly**	**Date:**	**April 14, 2022**
Subject:	**Review of BGC's Crooked Creek Stream Temperature Analysis – Response**		
Project No.:	**0011341**		

1.0 INTRODUCTION

In the spring of 2021, BGC Engineering Inc. (BGC) was retained by Donlin Gold to complete a quantitative analysis to define potential changes in Crooked Creek stream temperatures that may occur because of the proposed Donlin Gold Project (Project). Results of that analysis and the methodology used by BGC were provided to Donlin Gold in a draft report dated September 28, 2021. That report was subsequently submitted to the Alaska Department of Environmental Conservation (ADEC) for their consideration. ADEC also submitted the report to the Orutsaramiut Native Council (ONC) for comment, pursuant to the Order Granting Interlocutory Remand in *Orutsararmiut Native Council v. Alaska Department of Environmental Conservation*, No. 3AN-21-06502CI (Dec. 29, 2021).

Comments on BGC's September 28, 2021 report were received from Earthjustice (on behalf of the ONC) on March 29, 2022. Those comments include Exhibit 6, a technical memorandum prepared by Tom Myers, Ph.D. for Earthjustice. Dr. Myer's memorandum provides a technical review of BGC's analysis of potential changes in Crooked Creek stream temperatures that may occur because of the proposed Project. Donlin Gold has subsequently requested that BGC respond to Dr. Meyer's review comments. The following memorandum provides that requested response.

2.0 BGC RESPONSE TO MYER REVIEW COMMENTS

2.1. Comment 1 – Data Record

On Page 2 of this report, Dr. Meyer notes the following:

> *The first assumption is that stream flows will not be any lower than analyzed. The year 2005 had the lowest flows of the presented record but there is no indication as to the probability of those low flows being exceeded. If the background streamflow is lower than occurred in 2005, the mine would have more substantial effects on the stream temperatures than predicted by BGC.*

BGC did not make assumptions about stream flow or temperatures. Instead, BGC used actual continuous stream flow and temperature data, measured over the summer months for 5 years. It is clearly recognized that BGC's analysis does not include all potential combinations of streamflow

and stream temperature, given both the type of analysis conducted and the length of record available (2005, 2006, 2007, 2009 and 2011). However, it is not productive to replace the actual data with speculation about whether lower or higher levels might be observed. Actual data is a strong foundation for assessing likely future compliance with water quality standards. Moreover, Dr. Myers's comment assumes that there is a direct correlation between streamflow and stream temperatures. This assumption is not borne out by the actual observations. For example, the 2005 data includes two days with identical streamflow at CCAC (53.3 cfs on both July 23 and August 4). Despite identical streamflow on these two days, the stream temperatures were significantly different: 51.7°F on July 23 and 46.5°F on August 4. Because of these complexities, BGC's analysis focused on dates where corresponding streamflow and stream temperature data through the summer months in Crooked Creek, American Creek, and Anaconda Creek were available.

It is further noted that the available data does cover a wide range of summer stream temperatures in Crooked Creek, as demonstrated in Figure 2-1. Of the years analyzed, an average increase in stream temperature for the months of July and August was only predicted for 2005, with an average increase of 1°F. There was no predicted increase in average stream temperature for the other years analyzed (see Appendix C of BGC, September 28, 2021). Therefore, the analysis of BGC (September 28, 2021) provides a reasonable interpretation of a range of conditions, while recognizing that the analysis does not include every theoretically possible range of streamflow and stream temperature combinations.

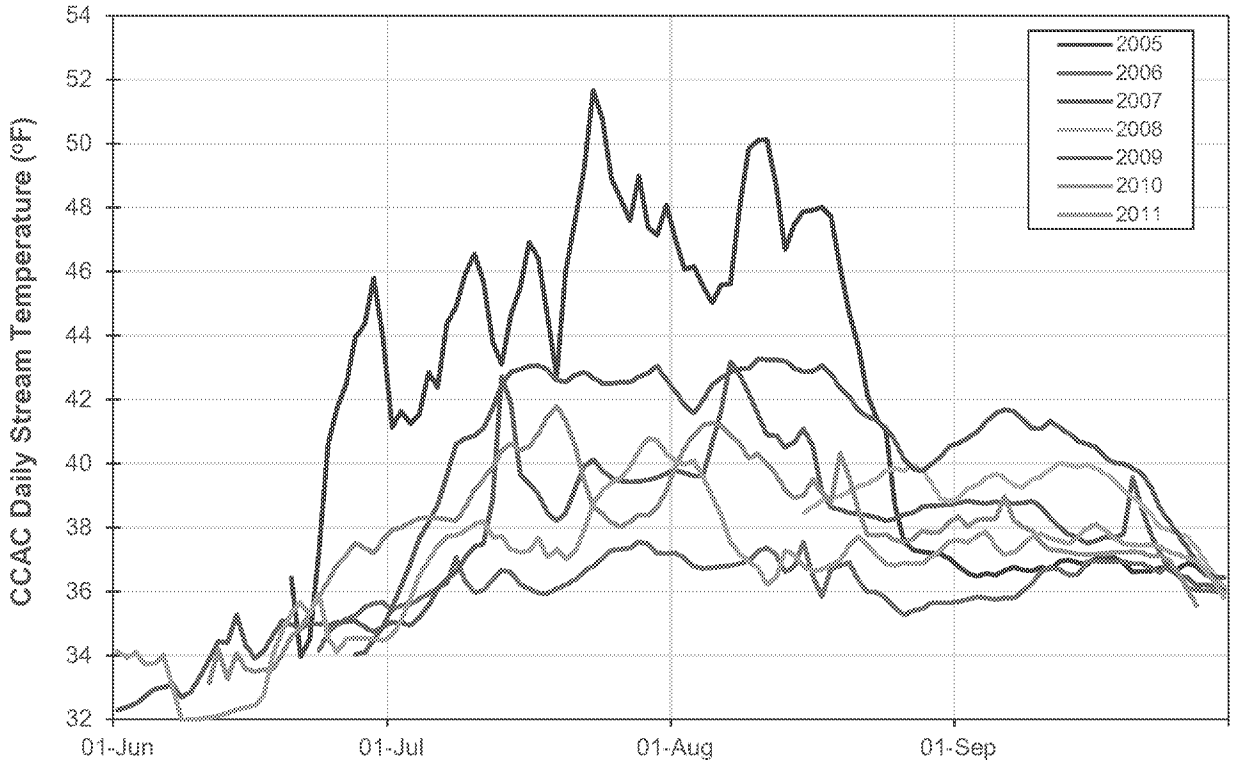

Figure 2-1. Crooked Creek daily stream temperature at CCAC for the period 2005-2011.

2.2. Comment 2 – Streamflow as a Function of Watershed Area

On Page 2 of his report, Dr. Meyer notes the following:

> *BGC assumed a linear flow to area relationship which means the stream gains flow as a function of area. While correct on a broad scale in the Donlin area, the reality is that the relationship varies with length and with the wetness in the watershed. During dry periods, most flow enters in select gaining reaches or at points of inflow. During storm runoff periods, for streams of this size and topography, there are probably discrete inflow points but they probably spread along the stream reach so the area relationship may be more accurate. BGC should have done a synoptic analysis on Crooked Creek to determine the actual relationship of flow with area during both wet and dry conditions.*

It is assumed that when referring to a synoptic study, Dr. Myer is describing coordinated, intensive sampling over a short time period (several days) during wet and dry periods where streamflow would be measured in Crooked Creek at a number of locations between American Creek and Anaconda Creek. A sensitivity analysis demonstrates that such additional streamflow data would not have a significant influence on the analysis.

BGC's September 28, 2021 analysis showed that the critical day with respect to maximum stream temperatures in the 2005-2011 period was July 23, 2005. Measured discharge on that day was 53.3 cfs at the Crooked Creek station (CCAC). Assuming a linear relationship between streamflow and watershed area, the discharge of Crooked Creek before the confluence with American Creek is estimated at 32.1 cfs, a difference of 21.2 cfs compared to CCAC. Of that 21.2 cfs, 8.8 cfs comes from American Creek and Anaconda Creek (pro-rated from AMER and ANDA). So, there is an assumed discharge of 12.4 cfs coming from other tributaries to Crooked Creek and valley sideslopes between American Creek and Anaconda Creek. As a sensitivity analysis, the contribution of these additional areas was varied using the following equation (Watt, 1989):

$$Q_2 = Q_1 \left(\frac{A_2}{A_1}\right)^n \qquad \text{[Eq. 2-1]}$$

where: Q_2 is the area-adjusted streamflow along Crooked Creek and Q_1 is the observed streamflow at station CCAC. A_2 represents the drainage area at the various modelling nodes along Crooked Creek and A_1 (111.9 mi^2) represents the drainage area at CCAC. As a sensitivity analysis, n was varied between 0.7 and 1.3.

Using an exponent of 0.7, the maximum modelled stream temperature on Crooked Creek on July 23, 2005 is 54.5°F, compared to 54.8°F as reported in BGC (September 28, 2021). Using an exponent of 1.3, the maximum modelled stream temperature on Crooked Creek on July 23, 2005 is 55.1°F, compared to 54.8°F. Therefore, even when accounting for a non-linear flow to watershed area relation, the impacts on stream temperature are relatively minor, with predicted stream temperatures in Crooked Creek remaining below the State of Alaska's water quality temperature standard of 55.4°F for egg/fry incubation in the years with available data.

2.3. Comment 3 – Failure to Consider Thermal Effects

On Page 3 of his report, Dr. Meyer notes the following:

> *The second assumption is there will be no thermal effects on the stream, meaning BGC ignored sources of heat that would add to stream temperatures. … At the latitude of Donlin, longwave atmospheric radiation and conduction of heat from the atmosphere during warm days are likely to be the largest source of heating. Shortwave radiation, including direct sunlight onto the creek, reflects from surface water such that at lower than a 30-degree angle little heat would be absorbed. Reflected shortwave radiation however could hit the riparian vegetation thereby heating it thereby increasing long-wave radiation to the creek. At the low temperatures considered here, evaporation would remove only a small amount of heat. It seems likely that at least during warm weather periods with long days there would be a net gain of heat in the creek. Additionally, the stream meanders substantially, as seen on BGC (2021) Figure 2-4; the meandering increases the surface area of the stream exposed to the factors listed above. By ignoring thermal effects, BGC ignored a substantial source of heat and has underestimated the temperature at the downstream end of the stream reach affected by the mine.*

Dr. Meyer's comment is overly simplistic in that the measured discharge and stream temperature at CCAC implicitly accounts for the upstream radiation impacts on stream temperature. With reference to Figure 2-2, BGC did not underestimate stream temperature at the downstream end of the reach given that stream temperature at CCAC is known and the estimated stream temperature at modelling node Q_1 is the stream temperature at CCAC minus the recorded temperature of Anaconda Creek water (ANDA). Also, accounting for thermal effects between model nodes Q_5 and Q_a would result in lower modelled stream temperatures in the vicinity of American Creek (i.e., less conservative results). Therefore, thermal effects have not been accounted for as they would result in less conservative results. Furthermore, riparian and stream conditions on Crooked Creek would not be directly impacted by the proposed Project.

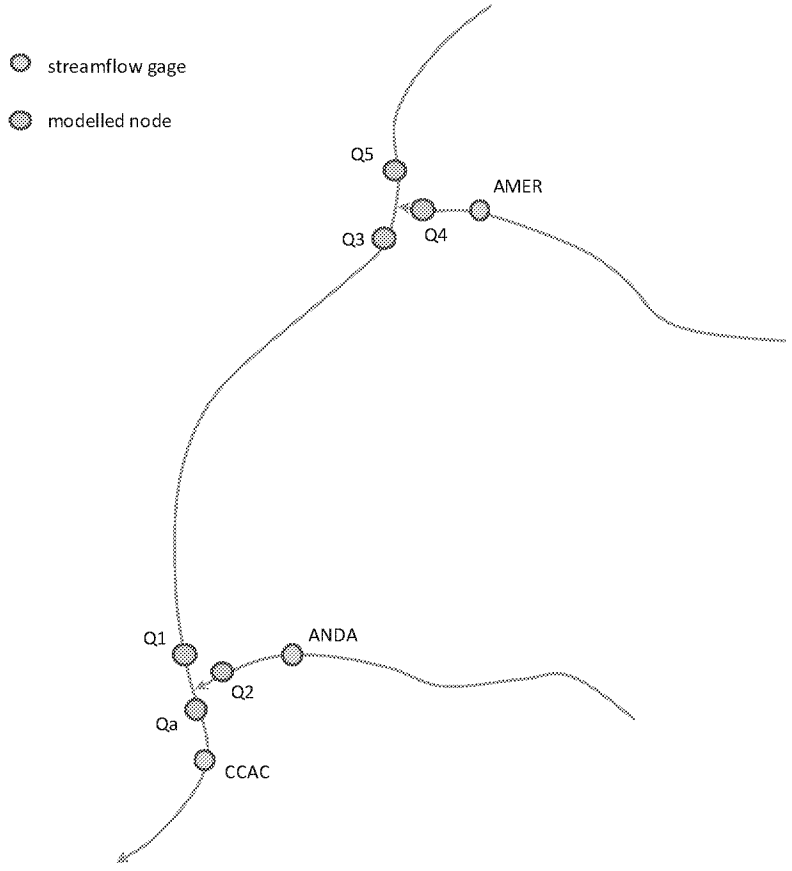

Figure 2-2. Modelling framework.

2.4. Comment 4 – Effluent Discharge to the Stream

On Page 3 of his report, Dr. Meyer notes the following:

> *The third unjustified assumption is that effluent temperatures would not be high enough to affect the stream. BGC provided no references to support the assumption. Effluent includes tailings decant water and runoff from waste rock and pit walls which could all be warmer than the stream temperatures during the summer due to radiation from the sun having warmed the source. There is also no discussion or evidence regarding heat that could be added to the water during treatment.*

The proposed water treatment includes a high-rate clarifier (HRC) and greensand filter, followed by reverse osmosis (RO). Neither of these treatment methods involve the addition of heat to the water. Therefore, the effluent temperature will generally be determined by the temperature of the water inputs fed through the water treatment plant (WTP). To date, Donlin Gold has not modelled what the potential range of the treated effluent could be. However, for the September 28, 2021 report, we assumed a temperature of 55°F for the treated effluent. This temperature is a very conservative (i.e., high) assumption because:

- The proposed treatment methods do not involve the application of heat to the process.
- A majority of the predicted treatment volumes are modelled to be sourced from perimeter pit groundwater wells (29%), in-pit groundwater wells (19%), and the TSF Seepage

Recovery System (SRS) (24%) (BGC, December 7, 2016). Together, these groundwater sources account for 72% of the modelled treatment volumes in July and August. As noted in BGC (September 28, 2011) groundwater has an average temperature of 35.6°F based on temperatures measured in the wells and vibrating wire piezometers installed in the immediate vicinity of the Donlin Project. Given that these three groundwater sources will be pumped directly to the WTP for treatment and will not be temporarily held in storage ponds, an assumed temperature of 55°F for the treated effluent is conservatively high.

Furthermore, Donlin Gold can control the temperature of the treated effluent by managing the quantity (i.e., flow) of the water sources that are fed to the WTP. That is, the temperature of the effluent could be made as low as, or close to, that of the source groundwater temperature (i.e., 35.6°F) by using groundwater alone, or warmed up by increasing the surface water sources (i.e., water stored in ponds). BGC's modeling showed that with a 40°F effluent, stream temperatures below the mine were reduced. This result suggests that ensuring the treated water is relatively cool could act as a potential mitigation strategy if monitored stream temperatures approach the Alaska water quality standard for egg/fry incubation.

2.5. Comment 5 – Climate Change

On Page 3 of his report, Dr. Meyer notes the following:

> *BGC also ignored the potential that climate change would affect the thermal factors considered above. It could affect the stream in two ways. It could decrease flows during warm, dry periods and increase the air temperature and therefore the flux of heat from the air to the water. Both would increase the stream temperature. Because climate change would affect the stream temperatures regardless of the mine, it is necessary to consider it as part of any analysis of the impacts of the mine.*

The intent of BGC's analysis was to model potential increases in Crooked Creek stream temperature as a result of mining operations using **available** streamflow and stream temperature data. It is clearly recognized that BGC's analysis does not include all potential combinations of streamflow and stream temperature, including the potential impacts of climate change, given both the type of analysis being conducted and the length of record available.

The highest stream temperature measured at CCAC during the 2005-2011 period was 51.7°F on July 23, 2005. Given the projected increases to air temperatures for northern climates in the coming century, it is possible that higher stream temperatures will occur in the future even if the Donlin Project does not proceed. At the same time, it is important to recognize that there is a non-linear relation between stream temperature and discharge, as demonstrated in Section 2.1. Regardless, there are strategies that Donlin Gold can implement, if needed, to mitigate the Project's possible impact on stream temperature especially given that the predicted inflow losses are relatively small compared to typical stream flows during the summer months. Potential monitoring and mitigation strategies include:

- Developing a monitoring program to measure streamflow and stream temperature at several locations along the study reach.

- Cooling treated effluent, if needed, to a target temperature prior to release to Crooked Creek.
- Releasing cooler, impounded water from the Snow Gulch Dam into Crooked Creek.
- Adding groundwater from newly developed wells outside the mine area.
- Assessing options to reduce the potential for the loss of water from the hyporheic zone of Crooked Creek due to the dewatering wells.

2.6. Comment 6 – Uncertainty in the Projections

On Pages 4, 5, and 6 of his report, Dr. Meyer states that BGC should have considered uncertainty for the following variables:

- Higher effluent temperatures
- Lower flow on Crooked Creek, which could make moderating temperatures on the effluent more difficult
- More cold water removed due to dewatering than the estimated 0.79 cfs.

The comment on higher effluent temperatures is addressed in Section 2.4. Effluent temperatures can be controlled by Donlin Gold and therefore represents a potential mitigation strategy.

We assume the second bullet refers to issues already addressed in Sections 2.1 and 2.2.

The final bullet refers to BGC's model assumption that the pit dewatering wells could remove 0.79 cfs from the hyporheic zone of Crooked Creek during operations, with the temperature of the captured water assumed to be at a typical groundwater temperature of 35.6°F. It is first noted that in BGC's analysis of September 28, 2021, a loss in Crooked Creek water of 2 cfs was entered into the calculation, rather than the actual value of 0.79 cfs. At the same time, the model results did not account for the potential loss of groundwater flows in smaller tributaries adjacent to the open pit BGC, May 6, 2016). From south to north these tributaries are Unnamed SE1, Omega Gulch, Queen Gulch, and Snow Gulch (see Figure 1 in BGC, May 6, 2016). Total average groundwater loss from these tributaries is approximately 0.34 cfs over the life-of-mine. Combined with the Crooked Creek losses of 0.79 cfs, the average loss in groundwater inflows is then 1.13 cfs. Looking at the maximum annual values over the life-of-mine, which would occur in about Year 20 (Table 1 of BGC, May 6, 2016), this value of 1.13 cfs increases to 1.66 cfs, which is less than the 2 cfs used in the September 28, 2021 report. Therefore, this effectively results in another area of conservativeness in the calculations – using a number above the predicted maximum annual value.

BGC's groundwater model analysis documented in the May 6, 2016 memorandum did include a sensitivity analysis where the alluvium hydraulic conductivity (K) was increased by a factor of 5. BGC found that the results were similar to those of the base case, with the exception that during the early Mine Years (-1 to 3) reductions in groundwater discharge and increases in stream leakage were higher for the sensitivity scenario. The greater alluvium K resulted in a quicker lowering of heads due to dewatering; however, the bedrock K, which remained unchanged from

the base case run limited the overall rate of groundwater flow towards the pit (i.e., limits the overall impacts).

If the amount of captured Crooked Creek streamflow and tributary groundwater flows is greater than anticipated, then the modelled maximum stream temperature would increase. However, any excess water captured by the pit dewatering wells would be sent to the WTP and discharged, as the mine is projected to operate with a water surplus. Further, as noted in Section 2.4, the assumed temperature of the treated effluent is conservative given its predominantly groundwater origin and the fact that Donlin Gold could control the temperature of the treated effluent.

3.0 CLOSURE

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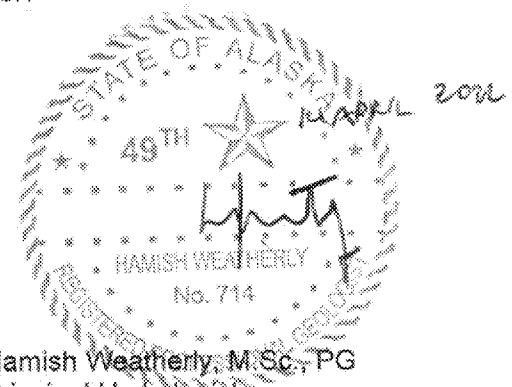
Yours sincerely,

BGC ENGINEERING INC.
per:



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HW/TWC

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EXECUTIVE OFFICE OF THE PRESIDENT

OFFICE OF SCIENCE AND TECHNOLOGY POLICY

COUNCIL ON ENVIRONMENTAL QUALITY

WASHINGTON, D.C.

November 15, 2021

MEMORANDUM FOR THE HEADS OF DEPARTMENTS AND AGENCIES

FROM: Eric S. Lander
President's Science Advisor and Director,
Office of Science and Technology Policy

Brenda Mallory
Chair, Council on Environmental Quality

SUBJECT: Indigenous Traditional Ecological Knowledge and Federal Decision Making

Background

President Biden is committed to strengthening the relationship between the Federal Government and Tribal Nations and to advancing equity for Indigenous people, including Native Americans, Alaska Natives, Native Hawaiians, and Indigenous peoples of the U.S. territories.[1] These commitments include ensuring that Federal agencies conduct regular, meaningful, and robust consultation with Tribal officials in the development of federal research, policies, and decisions, especially decisions that may affect Tribal Nations and the people they represent.

Consistent with the Administration's additional commitment to scientific integrity and knowledge- and evidence-based policymaking,[2] the White House Office of Science and Technology Policy (OSTP) and the White House Council on Environmental Quality (CEQ) issue this memorandum to recognize Indigenous Traditional Ecological Knowledge (ITEK)—a form of Indigenous Knowledge[3]—as one of the many important bodies of knowledge that contributes to the scientific, technical, social, and economic advancements of the United States and to our collective understanding of the natural world.

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[1] Memorandum on Tribal Consultation and Strengthening Nation-to-Nation Relationships, 86 Fed. Reg. 7,491 (Jan. 26, 2021); Executive Order 13,985: Advancing Racial Equity and Support for Underserved Communities Through the Federal Government, 86 Fed. Reg. 7,009 (Jan. 20, 2021); Executive Order 14,031: Advancing Equity, Justice, and Opportunity for Asian Americans, Native Hawaiians, and Pacific Islanders, 86 Fed. Reg. 29,675 (May 28, 2021).

[2] Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking (Jan. 27, 2021), https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/memorandum-on-restoring-trust-in-government-through-scientific-integrity-and-evidence-based-policymaking/.

[3] A variety of terms and definitions are used by knowledge holders, Indigenous people, Tribal organizations, and government bodies to refer to this body of knowledge or related concepts, including "Indigenous Knowledge," "Indigenous Knowledges," and "Traditional and Indigenous Knowledge." This memorandum will use "Indigenous Traditional Ecological Knowledge," or "ITEK," to refer to Indigenous Knowledge that pertains to ecology and the environment, although OSTP and CEQ intend to seek input on the appropriate terms to use in this context.

ITEK is a body of observations, oral and written knowledge, practices, and beliefs that promote environmental sustainability and the responsible stewardship of natural resources through relationships between humans and environmental systems. It is applied to phenomena across biological, physical, cultural and spiritual systems. ITEK has evolved over millennia, continues to evolve, and includes insights based on evidence acquired through direct contact with the environment and long-term experiences, as well as extensive observations, lessons, and skills passed from generation to generation. ITEK is owned by Indigenous people—including, but not limited to, Tribal Nations, Native Americans, Alaska Natives, and Native Hawaiians.[4]

The Federal Government has previously received requests to develop guidance for Federal agencies on how to partner with Tribal Nations and Native organizations regarding the application of ITEK.[5] The Administration recognizes that the Federal Government should engage with ITEK only through relationships with Tribal Nations and Native communities and in a manner that respects the rights of knowledge holders to control access to their knowledge, to grant or withhold permission, and to dictate the terms of its application. It further recognizes that, should Tribal Nations and Native communities decide to share ITEK and otherwise collaborate with the Federal Government, the Federal Government should ensure that the application of that knowledge and complementary collaborative efforts benefit Tribal Nations, Native communities, the United States, and our planet.

With these principles in mind, OSTP and CEQ are initiating a process to develop government-wide guidance for Federal agencies on ITEK, with Tribal consultation and drawing on the important work that has already occurred at a number of agencies and within Tribal Nations and Native communities. This memorandum is the first step in that process, which will be shaped by the input of Tribal Nations, ITEK holders and practitioners, Federal agency experts, and the public.

Indigenous Traditional Ecological Knowledge and Federal Decision Making

Where appropriate, ITEK can and should inform Federal decision making along with scientific inquiry. Indeed, the Fourth National Climate Assessment recognized and incorporated ITEK as an important information source for improving the understanding of climate change and environmental sustainability over time, and for developing comprehensive climate adaptation and natural resource management strategies.[6] As the examples provided at the end of this memorandum show, Tribal Nations and Native communities have already worked effectively

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[4] U.S. Fish & Wildlife Service, *Traditional Ecological Knowledge Fact Sheet* (Feb. 2011), https://www.fws.gov/nativeamerican/pdf/tek-fact-sheet.pdf; Inuit Circumpolar Council, *Indigenous Knowledge*, https://www.inuitcircumpolar.com/icc-activities/environment-sustainable-development/indigenous-knowledge/.

[5] National Congress of American Indians, *Request for Federal Government to Develop Guidance on Recognizing Tribal Sovereign Jurisdiction over Traditional Knowledge* (2013), https://www.ncai.org/resources/resolutions/request-for-federal-government-to-develop-guidance-on-recognizing-tribal-sovereign-jurisdiction-over-traditional-knowledge.

[6] Fourth National Climate Assessment, *Tribes and Indigenous Peoples*, Volume II, Chapter 15 (2018), https://nca2018.globalchange.gov/downloads/NCA4_Ch15_Tribes-and-Indigenous-Peoples_Full.pdf.

with Federal agencies to incorporate ITEK into knowledge- and evidence-based Federal Government decision making, and such collaborations have been mutually beneficial.

The guidance that OSTP and CEQ plan to develop—with Federal agency collaboration, robust and meaningful Tribal consultation, and input from ITEK holders and practitioners and the public—will include best practices on how to collaborate with Tribal Nations and Native communities around ITEK application to achieve mutually beneficial outcomes, how to address Federal Government-wide challenges around ITEK such as navigating Federal laws and interagency processes, and how to appropriately respect the knowledge holders' rights to decline participation in efforts to collaborate. The guidance will be designed to complement, not supplant, existing agency guidance related to ITEK and will build on past efforts to recognize and incorporate ITEK into Federal scientific and policy decisions.

Establishment of Interagency Working Group

OSTP and CEQ will begin in 2021 by developing pathways for Tribal and Native community input and convening an interagency working group to inform the development of the guidance. This "Interagency Working Group on Indigenous Traditional Ecological Knowledge" will include representatives from agencies across the Federal Government. The purpose of the working group is to enhance interagency collaboration and coordination, draw on agency experience, and address significant issues as they arise. The Interagency Working Group on Indigenous Traditional Ecological Knowledge will prepare the guidance document for planned release in 2022.

OSTP and CEQ look forward to collaborating with Tribal Nations and Native communities to apply ITEK in a way that benefits people and the planet and facilitates a holistic understanding of the world.

APPENDIX: Supporting Examples of ITEK Application and Collaboration Between Native Communities and the Federal Government, Written With Native Partners

The Administration recognizes that, for generations, Federal policies have systematically sought to assimilate and displace Indigenous people and to eradicate Indigenous cultures. The below examples are intended not to erase this history, but to illustrate the kinds of mutually beneficial collaborations that are possible. These examples include input from and reflect the perspectives of the Native organizations, individuals, and agencies involved in these particular efforts.

- Coastal Indian Tribes, including the Cowlitz Indian Tribe, have fished and traded for eulachon in tributaries of the Columbia River since time immemorial. NOAA and the Cowlitz Indian Tribe—who initiated the project—applied Tribal oral histories to reconstruct historic distributions of the eulachon, a species of fish.[7] Those Cowlitz Tribal oral histories aided in identification of key spawning habitat, timing of eulachon runs, and run differences between tributaries and directly informed NOAA's decision to list a population segment as threatened under the Endangered Species Act.[8] The project facilitated joint efforts to identify and protect critical habitat, increase abundance of the species, and promote species recovery.[9]
- In Acadia National Park, the National Park Service is working with citizens of Wabanaki Tribes—the Aroostook Band of Micmacs, the Houlton Band of Maliseets, the Passamaquoddy Tribe at Sipayak, the Passamaquoddy Tribe at Indian Township, and the Penobscot Indian Nation—on shared governance and research on sweetgrass harvesting.[10] Wabanaki people have harvested sweetgrass for generations. Research in Acadia, guided by Indigenous methodologies, reinforces what Wabanaki people have always known: that harvesting sweetgrass through a Wabanaki philosophy enhances sweetgrass abundance. Wabanaki knowledge, and the gatherers who generate this knowledge, are leading NPS research and management strategies that will enable restoration of Wabanaki harvesting within Acadia National Park.[11]
- For Native Hawaiians, cultural heritage and the natural world are valued as one. At Papahānaumokuākea Marine National Monument in the Northwestern Hawaiian Islands, this ancestral, cultural, and natural significance are on an equal platform with all other

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[7] Nathan Reynolds, Marc Romano, *Traditional Ecological Knowledge: Reconstructing Historical Run Timing and Spawning Distribution of Eulachon through Tribal Oral History*, Journal of Northwest Anthropology (2013).

[8] National Marine Fisheries Service, *Recovery Plan for the Southern Distinct Population Segment of Eulachon*, (Sept. 2017), https://repository.library.noaa.gov/view/noaa/15989.

[9] NOAA Fisheries, National Ocean Service, *Guidance and Best Practices for Engaging and Incorporating Traditional Ecological Knowledge in Decision-Making* (May 2019), https://www.legislative.noaa.gov/docs/19-065933-Traditional-Knowledge-in-Decision-Making-Document-Signed.pdf.

[10] U.S. Forest Service Southern Research Station, *Traditional Ecological Knowledge Helps Researchers Understand the Effects of Plant Harvesting* (2018), https://srs.fs.usda.gov/research/2018-research-highlights/highlight.php?id=traditional-knowledge.

[11] Abbe Museum, *Wabanaki Sweetgrass Harvesting in Acadia National Park* (June 1, 2019), https://www.abbemuseum.org/blog/2018/6/21/a8ox8s8wxde6nenklfm77gayl60h87.

interests.[12] The monument is co-managed by the National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, the State of Hawai'i Office of Hawaiian Affairs, and the Hawai'i Department of Land and Natural Resources, and Native Hawaiians have consistently led the development and governance of the monument. Its management is based on Indigenous Hawaiian Knowledge and management practices, as expressed in the recent release of Mai Ka Pō Mai, a historic guidance document that will help federal and state agencies further integrate Native Hawaiian culture into all aspects of management.[13]

- The Inupiat, St. Lawrence Island Yupik, Central Yup'ik and Cup'ik peoples have lived in the Northern Bering Sea region for millennia interconnected with marine and coastal ecosystems. Tribes, regional Alaska native non-profit organizations, Elders and Traditional Knowledge holders from across the northern Bering Sea region worked with the Federal government over concerns about rapid climate change and the need for solutions that take a whole-of-government approach that build equity in decision-making for the Northern Bering Sea region. The Northern Bering Sea Climate Resilience Area, established by Executive Order 13,754 in 2016, and reinstated by President Biden in 2021, provides an example of Indigenous values informing policy and the potential for including Traditional Knowledge in decision-making.[14] It provides a model for bridging different value systems coming from Indigenous Knowledge and academic science through a framework that includes a federal task force and Bering Intergovernmental Tribal Advisory Council. The task force and advisory council are charged with conserving the region's ecosystem, including those natural resources that provide important food security to the people of the region. It also provides a pathway for Tribal voices that have been historically underserved in decision-making processes.

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[12] Papahānaumokuākea Marine National Monument, *2020 State of the Monument Report* (2020), https://sanctuaries.noaa.gov/science/condition/pmnm/welcome.html

[13] Papahānaumokuākea Marine National Monument, *Integrating Native Hawaiian Culture into Management of Papahānaumokuākea* (June 21, 2021), https://www.papahanaumokuakea.gov/new-news/2021/06/21/maikapomai/.

[14] Executive Order 13,754: Northern Bering Sea Climate Resilience, 81 Fed. Reg. 90,669 (Dec. 9. 2016); Press Release: Biden-Harris Administration Brings Arctic Policy to the Forefront (Sept. 24, 2021), https://www.whitehouse.gov/ostp/news-updates/2021/09/24/biden-harris-administration-brings-arctic-policy-to-the-forefront-with-reactivated-steering-committee-new-slate-of-research-commissioners/.

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Forest Fire Effects on Mercury Deposition in the Boreal Forest

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8/19/2022

To whom it may concern,

Speaking of the consultation for the EIS process, I think that the information that was supposed to go to the tribes got there and some of the tribes did not react fast enough.

Tribal meetings are usually once a month for our Governments, and in the summer when it happens people are more worried about harvest for getting ready for the winter.

I read and heard in the news about all the things that were developed and there's a significant number of breaches that have happened over the years in different parts of the world. In bazile, Mount Polley, and other places all over the world.

Before these things happened all over the world, these people lived in harmony and this is changing in my own time.People are more into the dollar. If we look at the seven generations down the line, the safe guards they are using today, what will happen 60-70 years down the line, and these aren't proven methods.

There's climate change happening, and this part of the area is worst hit.There is change in the landscape around here. We're seeing it in real time.

These are things that I see, food security is one of the more important things that we should worry about, what are we going to do when it's gone. The land mammals and sea foods that we used for ages.

It's getting important to the point where our leadership is more aware of the system and how it works, but at the same time not enough people are aware of how to make a difference to get the word to the people who need to hear.

We look at the money system that's in place and it's not working. It's working for commercial aspects and we really need to take a look at our own food security. Why are the salmon numbers diminishing and not showing up?

With prices already skyrocketing in our villages, food security is our primary concern and we need to preserve what we have.

If it's going to hurt our livelihood it's something that is going to hurt us.

s/ Fred Phillip

Fred Phillip
Elder and Tribal Member
Native Village of Kwigillingok

August 19, 2022

To whom it may concern,

Traditional knowledge was not used in consideration of the EIS process. In our region we are quiet and humble in all aspects of life. This thing that we're doing is important because it affects our kids and we need to consider that. Snowfall isn't the same yearly, but there's always runoff from the annual spring melt.

The process wasn't sufficient for us. Calista didn't follow through, we are after borns to the 1971 law, but the overall consensus of Donlin to the YK-Delta, we don't like it.

There was no vote, only behind closed doors.

In itself, the whole process was a failure, they were supposed to come to certain villages and do that, but during that time it was blizzard conditions and other tribes were going through their changes during the comment period.

It's common all over the delta for all Tribes that the Tribal Administrators become overwhelmed and fatigued, so for us, there wasn't a solid avenue for us to receive information on this process. This is something that wasn't taken into consideration.

I recall late David David mentioning this in public meetings in the early 2000's and 2010's, that each year, there is considerable snowfall in the interior and there is always snow runoff to our streams and rivers. Even if they have all of these considerations to retain the waste. There will always be runoff that affects the food we gather.

Treatment of water will be forever, when we're gone and they'll still be treating the water. Even if they had recommended dry stack tailings, they're still doing the tailings pond. This is such disrespect to us.

s/Gavin Phillip

Gavin Phillip
President
Native Village of Kwigillingok

August 18, 2022

To whom it may concern,

The Army Corps did not give us enough consultation for people to speak their mind on the EIS. It was too short. They gave us a couple of weeks, but by the time we were meeting about the EIS, the EIS period was already gone. It was too short for consultation, they should give us at least a month to look at the EIS and discuss it with our people in the region. We want more time to look at what they're proposing.

My father-in-law told me and the people in tribal council with him that, if any mine development starts in our region, it would affect us detrimentally. The open pit mine would put dust contaminants into the air and affect the region by eliminating berries that grow and the fish that swim in our rivers. Affecting the fish and game on the Kuskokwim river drastically due to the chemicals they will be using. The tailings pond will be in that spot for a long time and will eventually fail, contaminating the river.

We are worried for our future generations survival, and we want this to be a source of food security for our future.

A couple of weeks for comment is not enough for our council. We need more time to think about and speak with our community on what they are doing.

s/ Noah Wise

Noah Wise
President | Mayor
Native Village of Nunapitchuk

8/19/2022

To whom it may concern,

From the period of the draft until the final EIS, there was a period of silence, we didn't know what was going on or that they were still working on this EIS. Calista, Donlin, and the others involved only went to specific villages, not every village from the region.

In 2015 we got together for the Draft EIS.
Calista flew us out with a charter to Hooper Bay, with myself and one other from our Chevak Council. During this first meeting, the Army Corps presented and after, the topic of discussion was primarily the promise of jobs and really nothing else.

When it came to a follow up meeting, we brought a couple younger people from our council, who had snow machines and could drive with us out to Hooper Bay. We had to go through a blizzard to make it to this meeting, so not everyone invited was able to attend. At this meeting they gave us a couple more things, and the Hooper Bay Council said, as long as it won't interfere with our subsistence here because our sea is our grocery store.

When the final EIS came out in 2018, we were given a 10,668 page record of decision, with only a 30 day comment period. I couldn't read that in only 30 days.

The decision was made that way. We didn't have enough time to review it.

When our leaders came forward for discussion, it was about being given a foot wide book that compares to the length of a pilot bread cracker box, with only 30 days to look at it. Because it was so big, and a short time to comment, it was a done deal. This gave the green light to everyone.

The permitting process that was done in increments, was not looking at the big picture.

I feel the EIS and how they did it, doesn't put anything on the actual risks against the environment. That was in 2018 and a week before it was released, I heard of a tailings dam failure by the same company operating in Brazil and over 200 people died.

Another comparison, BLM, opened up mineral exploration and said that they did consultation, but it was during the start of the COVID-19 pandemic, while our villages were in lockdown and no travel was happening. They still pushed through, they came out and had these consultations and moved forward. Opening our BLM lands to exploration.

It's common for us to have the rug swept out from under us with these agencies and prospectors to move forward on their permitting process.

An elder told us once, they are going to take away a whole mountain. If those drill holes are leaking toxins into where they dug, if they take away a whole mountain - how much toxins with that make?

Tribal consultation on these big projects needs to be all inclusive to every village. And comment periods should be longer, especially if we're given a 10,668 page ROD to comment on.

s/Richard Slats

RB Slats
Secretary
Chevak Native Village